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OHIO RIVER BASIN COMPREHENSIVE SURVEY. VOLUME IV. APPENDIX C. H--ETC(U)

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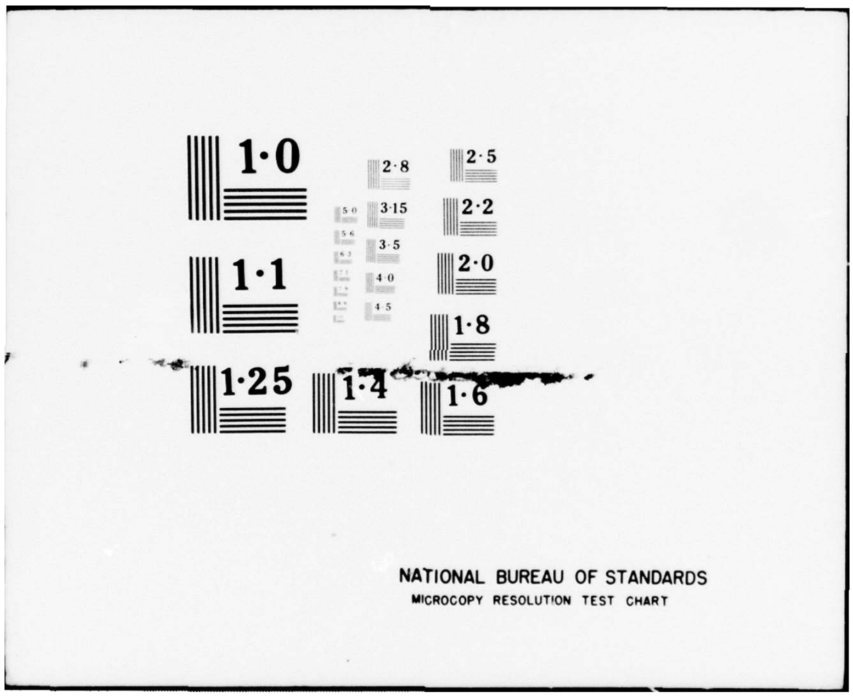
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MICROCOPY RESOLUTION TEST CHART

VOLUME IV

OHIO RIVER BASIN

COMPREHENSIVE SURVEY

Appendix C

HYDROLOGY

Prepared by U.S. Army Engineer Division, Ohio River in cooperation with Departments of Agriculture; Commerce; Health, Education and Welfare; Interior; the Federal Power Commission and participating states.

U.S. ARMY ENGINEER DIVISION, OHIO RIVER-CINCINNATI, OHIO

OHIO RIVER BASIN COMPREHENSIVE SURVEY
HYDROLOGY
Vol. IV App. C

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HYDROLOGY
OF THE
OHIO RIVER BASIN

6

APPENDIX C
OHIO RIVER BASIN COMPREHENSIVE SURVEY.

Volume IV.
Appendix C.
Hydrology.

Prepared by

The Corps of Engineers
U.S. Army Engineer Division, Ohio River
Cincinnati, Ohio

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SECTION I - INTRODUCTION

1. Scope. This appendix contains climatologic and hydrologic data pertinent to the analysis of water and related land resource problems in the Ohio River Basin and formulation of a comprehensive framework plan for their solution.

2. Purpose. The data presented provide the basis for discussion of water problems and solutions contained in other appendices and in sections of the main report. Precipitation and stream flow data are given, the magnitude and frequency of floods and the frequency of low flows are developed for the Basin. The effects of the Corps of Engineers present plan of development on the reduction of flood flows and augmentation of low flows on the Ohio River are determined, and availability of water is also estimated. Data provided by the U.S. Soil Conservation Service have been included in this appendix as representative coverage of upstream watershed areas.

SECTION II - BASIN DESCRIPTION

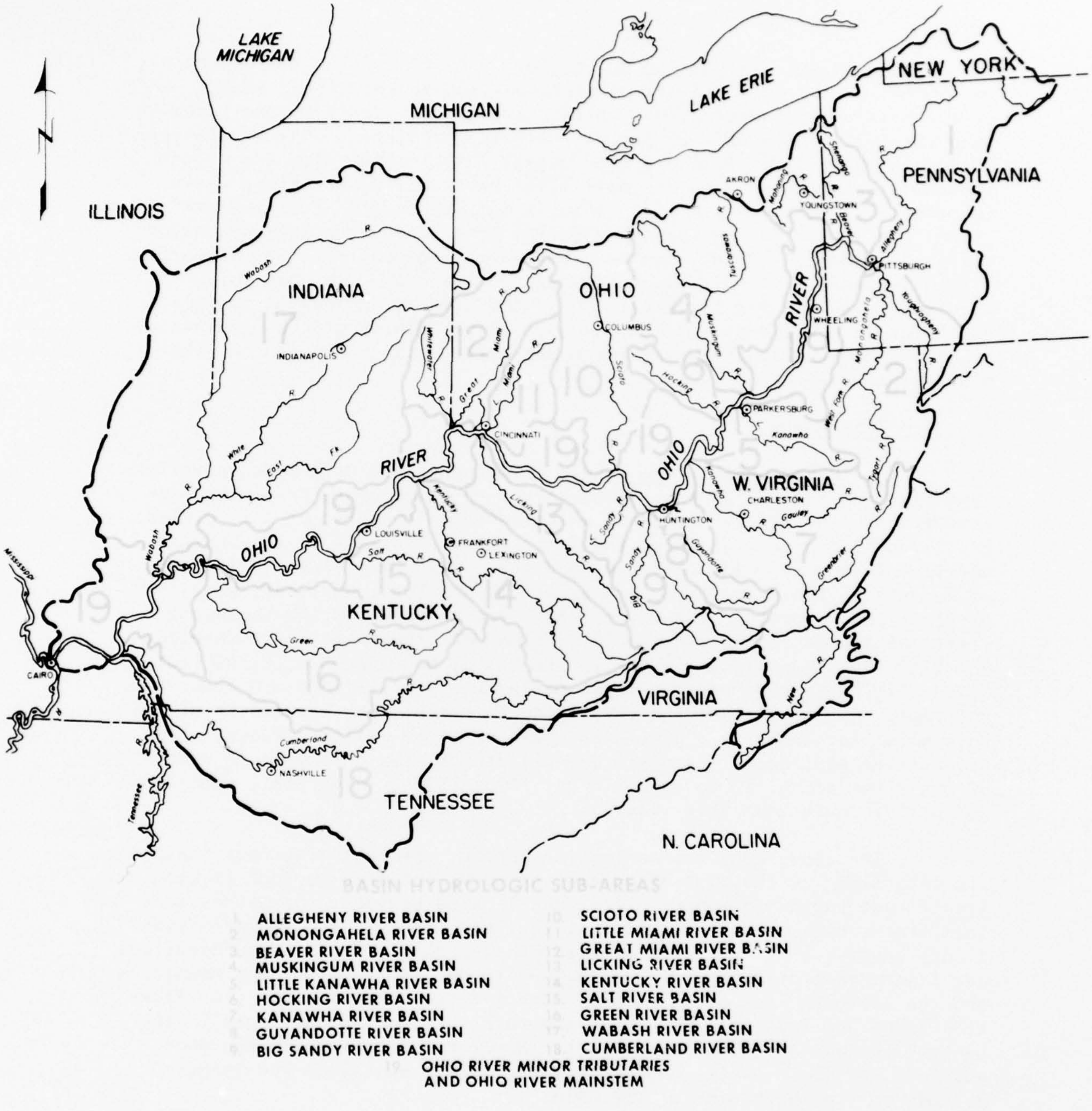
3. Location, Orientation and Extent. The Ohio River Basin, shown on Figure 1, lies in the middle eastern portion of the United States, east of the Mississippi River. The drainage from that river's system flows into the Gulf of Mexico. Of the six natural divisions of the Mississippi Basin, the Ohio River Basin is the largest in volume of flow and is exceeded in area only by the Missouri River Basin. The Ohio River Basin Comprehensive Survey study area contains 163,000 square miles and excludes the 40,910 in the Tennessee Basin. The study area includes major portions of Ohio, Indiana, Kentucky and West Virginia, substantial parts of Pennsylvania, Illinois and Tennessee and small areas of New York, Maryland, Virginia and North Carolina. The area is bounded on the north by the Great Lakes drainage, on the east by the divide of the Appalachian Mountains, on the south by the Tennessee Valley and on the west by the Mississippi River.

4. Topography.

a. Physiographic Provinces. The topography of the Basin varies from flat and rolling plains to mountains. Physiographic provinces represented are the Central Lowland, which contains the glacial till plains of Illinois, Indiana and Ohio; the Interior Low Plateaus in the western portion of Tennessee and Kentucky, and the Appalachian Plateau, in parts of Tennessee, Kentucky, Ohio, Pennsylvania, New York, Maryland, West Virginia and Virginia. The Valley and Ridge province on the southeast limits of the Basin contains small portions of Tennessee, North Carolina and Virginia. The highest point in the Basin, Mount Rogers, 5,720 feet, is in Virginia, the lowest point at Cairo, where elevations are about 310 feet. Figure 2 shows the physiographic areas. The area north of the Ohio River is generally a glaciated plain of minor relief. However, the unglaciated portion on the north and all of the area on the south side of the river are hilly to mountainous. Glaciation, in general, extended no further south than this river.

The topography influences the runoff. Since the surface features are determined by the type of underlying rock, the area geology is also a significant factor in runoff. The consolidated geologic formations contain limestones, sandstones, slates, coal and shales. The higher elevations, greater precipitation, steeper slopes, poor ground water formations and lower evaporation are aids to higher runoff in the Allegheny Mountains and the southern part of the Basin. The flatter slopes, higher infiltration rates and less rainfall cause the surface runoff to be lower in the central lowland and glaciated plains. However, glacial soils are good aquifers and low flow is considerably higher and sustained for longer periods on the north side of the Ohio.

b. Vegetation. The area was entirely forested prior to clearing by pioneers. Today, forest vegetation consists of pines and oaks on the ridges and hardwoods and hemlocks in the bottoms. Precipitation and



BASIN HYDROLOGIC SUB-AREAS

1. ALLEGHENY RIVER BASIN
2. MONONGAHELA RIVER BASIN
3. BEAVER RIVER BASIN
4. MUSKINGUM RIVER BASIN
5. LITTLE KANAWHA RIVER BASIN
6. HOCKING RIVER BASIN
7. KANAWHA RIVER BASIN
8. GUYANDOTTE RIVER BASIN
9. BIG SANDY RIVER BASIN
10. SCIOTO RIVER BASIN
11. LITTLE MIAMI RIVER BASIN
12. GREAT MIAMI RIVER BASIN
13. LICKING RIVER BASIN
14. KENTUCKY RIVER BASIN
15. SALT RIVER BASIN
16. GREEN RIVER BASIN
17. WABASH RIVER BASIN
18. CUMBERLAND RIVER BASIN
19. OHIO RIVER MINOR TRIBUTARIES AND OHIO RIVER MAINSTEM

BASIN BOUNDARY

STATE BOUNDARY

HYDROLOGIC SUB-AREA BOUNDARY

CITY

OHIO RIVER BASIN HYDROLOGIC SUB-AREA MAP

SCALE IN MILES

50 25 0 50 100

FIGURE 1

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Adapted from:

Fenneman, N.M., 1938, Physiography of eastern United States: New York, McGraw-Hill Book Company.

Hendrickson, G.E., 1958, Summary of occurrence of ground water in Kentucky: U.S. Geol. Survey Hydrol. Inv. Atlas HA-10.

Raisz, Erwin, 1957, Land forms of the United States: Map, sixth revised edition.

Southern limit of Continental Glaciation

OHIO RIVER BASIN
PHYSIOGRAPHIC REGIONS

FIGURE 2

temperatures in the Basin are ideal for tree survival, therefore, an exceptionally large number of these species exist.

On the cleared lands are cultivated crops such as corn, wheat, hay, soy beans and tobacco, or pasture. With the exception of strip mining areas, freshly plowed and cultivated fields on steep slopes, the vegetation is generally sufficient to retard runoff and minimize erosion.

The stream channels are generally free of vegetation, but the overbank areas are covered with trees, brush and other growth. Roughness coefficients for the streams cover the complete range of values from those used for very straight clear streams to channels which are hardly discernible and are tree- and weed-choked.

5. Stream Patterns and Channel Characteristics.

a. Drainage Patterns and Areas. The streams in the Ohio Basin, except those in the glaciated areas, are essentially remnants of a pattern formed on a peneplain, which sloped to the north and west. The present incised pattern in many areas still exhibits the general meandering of these former mature streams, although slopes are steeper and valleys are narrower. The Monongahela, Allegheny and Upper Ohio Rivers were originally part of the St. Lawrence River drainage flowing to Lake Erie. With the exception of the Upper Allegheny, these rivers flowed north through the Beaver and Grand River Valleys. The Big Sandy River was probably the original outlet for the Upper Kanawha, which then flowed through the preglacial "Teays" Valley, up the present Scioto River, across Indiana and Illinois and into the Mississippi River. The Ohio from near Maysville, Ky., to Cairo is essentially in its original location with the exception of some changes, such as at Cincinnati, caused by glaciation. The several periods of glaciation cut off the drainage to the north, hence the Ohio River became the main outlet from the south. Each glaciation produced changes in the stream patterns and many systems in Illinois, Indiana, Ohio and Pennsylvania were reversed, adding to the Ohio River's flow, especially as the ice melted.

The main stem of the Ohio is formed by the junction of the Allegheny and Monongahela Rivers at Pittsburgh and then flows in a general southwesterly direction for 981 miles to Cairo, where it joins the Mississippi. The Figure 1 map also shows the Ohio River, its major tributaries and limits of the Basin. The drainage area at Pittsburgh is 19,100 square miles. At the mouth of the Kanawha River, 266 miles downstream, it increases to 52,760, including the 12,200 in the Kanawha Basin. At Cincinnati, it is 76,580, including 3,670 in the Licking Basin which joins the Ohio there. At Louisville, the figure is 91,170 and 107,000 at Evansville, upstream of the Wabash River. The Wabash River Basin contributes an additional 33,100, the Cumberland 17,920, and the Tennessee 40,910, which, together with the smaller tributaries and direct drainage to the Ohio, results in the 203,940 square-mile drainage area at the mouth.

Major tributaries entering from the north are the Beaver, Muskingum, Hocking, Scioto, Little Miami, Great Miami and Wabash Rivers.

Streams from the more mountainous area on the south are the Little Kanawha, Kanawha, Guyandotte, Twelvepole, Big Sandy, Little Sandy, Licking, Kentucky, Salt, Green, Cumberland and Tennessee. Table 1 lists the drainage areas at the mouth for each major tributary and river distances along the Ohio main stem at the junctions.

b. Stream Slopes, Cross Sectional Dimensions, Channel Capacities and Flood Stages. Streams in the Ohio Basin vary from very steep mountain ones with cascades and rapids to very sluggish, meandering, marsh-like areas. Slopes of major tributaries vary from more than 100 feet per mile in the headwaters to less than two-tenths of a foot in the flat areas near the main stem. In general the streams are considerably steeper in the headwaters, becoming relatively level near the mouth. Post-glacial changes in stream patterns, local layers of hard rock and distribution of tributaries may cause local modifications in profiles. In areas of glacial deposition in Indiana, remnants of marshes and bogs may result in relatively flat and sluggish upstream areas, the intermediate reach being the steepest. For areas of similar topography, the slope is related to the drainage area, becoming steeper as that becomes smaller. Average slopes for the various tributaries are greatest for streams in the Allegheny Mountains, and least for the glaciated plateaus on the north side of the Ohio. Various slopes for the main portions of the major tributaries are given in Table 2. Water surfaces in navigation pools are not considered.

The ratio of width to depth of a stream usually is related to its steepness. The steeper ones are narrower, whereas the sluggish courses for the same size drainage area are considerably wider. Unglaciated headwater streams are usually steep and tend to occupy the notch at the base of a V-shaped cross section. Stream banks are narrow or absent and floodwaters fill the entire bottom of the valley. The more mature streams occupy broad valleys in which the channel fills only a small portion except during flood stage. The valley widths vary, being narrow in harder rock areas and wider in the more easily eroded material, where banks are also usually unstable. Several terraces or flood plains may be developed at various elevations. In the glaciated areas, many new channels were formed after the stream valleys were obliterated under sediments. In a few cases the new streams may have been re-established in the old drainage patterns for short distances. In the moraine areas of ice wastage, lakes and swamps were formed which exhibit wide cross sections. The upper northern tributaries of the Wabash, Tippecanoe and Eel Rivers are typical of this type of topography. In the middle reaches, new streams were shaped atop the glacial till. Nowhere in this middle region do the streams extend into the underlying consolidated rocks. In the southern part of the glaciated plateau the streams have cut up the glacial plain and profiles, and cross sections are those of more recent ones. Near the Ohio River the streams have generally cut through the glacial debris into the harder rock, and stream valleys tend to be narrower. The new branches are generally steep, have V-shaped valleys and are relatively straight.

The streams on the south side of the Ohio River meander. The mouths of Tygarts Creek and Little Sandy River indicate remnants of streams which had much larger drainage areas. The present locations, at least near the Ohio River, were near base level of erosion not so long ago. This is revealed by meanders and oxbow lakes superimposed on the former wide valley. The recent stream valleys, however, are not developed to the width which had accompanied the original meander limits.

The flood plain is the relatively flat lowland adjoining a water course and is needed periodically to carry some of the flow. A river generally excavates a channel that can carry within its banks flows up to the peak discharges that occur on the average about twice a year. Higher flows are taken care of by the flood plain. Frequency of stream discharge and related flooding depth on these plains can generally be determined.

Flood stage is a term commonly used by the U.S. Weather Bureau and others. It designates that stage, on a fixed river gage, at which overflow of the natural banks of the stream begins to cause damages in any selected portion of the reach. The flood stage at various locations is given in the publication of the U.S. Department of Commerce, Weather Bureau, Daily River Stages.

c. Stream Characteristics. The main stem of the Ohio River falls 429 feet in its 981-mile course from Pittsburgh to Cairo. It flows in a general southwest direction, but this varies considerably, changing to all points from north to south in relatively short reaches. The valley is rather narrow for the size of the drainage area reflecting the glacial changes. It ranges in average width from less than a half mile in the Pittsburgh to Wheeling reach to more than a mile between Cincinnati and Louisville. At Louisville, it widens to about four miles and then contracts to a mile below the Salt River. Near the mouth, it again widens to six to eight miles. Elevations vary from 100 to 600 feet below the plateaus surrounding the valley. The only falls are at Louisville, where a 25-foot difference in water surface between the upper and lower pools existed prior to canalization.

Canalization of the Ohio was completed in 1929. The original systems of 46 locks and dams is being replaced by 19 authorized or completed higher lift structures. Their purpose is to form a series of pools by which river traffic can pass from one to another aided by locks, making the system virtually a series of "water stairs". These navigation aids will have no essential effect on flood stages. When flow may be 50 to 200 times or more the minimum flows during the year, the gates on the new dams will fully open.

The following descriptions of seven typical Ohio River tributary stream reaches give characteristics of the valley and stream cross sections that are representative of all major sub-basins:

(1) The Allegheny River valley in its upper reaches is relatively narrow, whereas in the middle portion it is from one-half to more than a mile wide, although the water surface at normal stage is about

600 feet. Near Pittsburgh, the valley is about one-half mile wide and the navigation pool averages about 800 feet. The banks in many reaches are generally from a few feet to eight above normal water surface and are moderately to heavily wooded.

(2) The upper reach of the Monongahela is within the Allegheny Mountains and slopes are very steep. In the middle reaches the flood plain is narrow, but high level erosion terraces occur along the valley sides in the lower part. The Cheat River, after it leaves the terraced area, flows through a deep gorge as it nears its junction with the Monongahela. In the upper reaches the banks are rocky, channels are filled with cobbles and boulders and stream velocities are high. Near the mouth, flow velocities are more moderate and channel deposits are fine-grained.

(3) The Kanawha below Kanawha Falls is 500 to 800 feet wide at normal stage, while the valley is wider with rounded hills. The flood plain is from 12 to 50 feet above normal water surface and the banks have relatively steep slopes to the water's edge. The upper tributary stream channels are considerably steeper and narrower. The Gauley River width varies from 50 feet in the upstream reaches to 400 near its mouth. The stream banks range from five to 10 feet near the source to 20 to 30 near the mouth.

(4) The Scioto upper or summit reach is a high, flat, poorly-drained, glaciated plateau with marsh lands and badly developed channels that are inadequate for high flows. Between Prospect and Columbus, the river is confined between steep banks with practically no flood plain. South of Columbus the stream is flanked by level plains of rich farm land up to three and one-half miles wide in some places. Slopes from hills to stream beds are sharp and in some cases precipitous, in this alluvial section. In places along the lower Scioto there are two or three distinct terraces which are flat or slope gently toward the water. They are composed of sands and gravels and are glacial period in origin. The entire area is presently sparsely wooded.

(5) The Great Miami valleys above Dayton are narrow and comparatively shallow, whereas below they are broad and comparatively open. The surrounding country is level or rolling, with but little forestation.

(6) The Wabash, from its source to the town of Wabash, flows in a narrow, shallow valley with the depth increasing downstream. In this reach the flood plain ranges in width from a few hundred feet to one-half mile, with a gradual slope from the bank to the hill line. A few miles below Wabash, the valley widens rapidly and reaches a maximum of about eight miles a short distance south of Vincennes. The actual channel width increases from approximately 500 to 800 feet from Lafayette to Terre Haute. The bottom lands become flatter and in some areas the elevation of the flood plain is slightly less at some distance from the river than adjacent to the bank. Near the mouth, the flood plain contains

numerous marshes and old meanders left by natural channel changes. Here the valley is about six miles wide, and the channel 1,200 feet. The greater part of the valley is inundated during floods. The average distance from the bank to the low-water line generally varies from 14 feet near Bluffton to 18 near the mouth, with greater or lesser amounts at specific locations.

(7) The Kentucky flows through a mountainous area in the upper third of the Basin and streams in the remainder are in deep valleys. The area known as the Bluegrass Region, extending from the middle of the Basin downstream, is gently rolling, has little woodland but is covered with rich limestone soils. The lower part of the Basin is topographically rougher and has poor soils, with agriculture confined to the flood plains. Throughout the Basin relatively steep slopes flank the main stem and tributaries. In many areas this stream is confined in gorge sections with precipitous, rock-faced valley walls. The Kentucky meanders considerably and varies from a width of 250 feet in the navigable portion to 100 on the North Fork at Jackson. The valley width is one and one-quarter miles near the mouth, 300 to 400 feet at Frankfort and 600 to 700 near Jackson.

SECTION III - CLIMATE AND METEOROLOGY

6. General Climate. The Ohio Basin climate is marked by moderate extremes of heat and cold and dryness and wetness. It is part of the humid eastern United States and is considered to have a climatic water surplus. The weather systems usually pass from west to east, and the air may be greatly chilled in winter, or heated in summer, by passage over vast stretches of land. Abrupt changes may occur and spring and summer thunderstorms with intense rains of short duration are common. Summers are moderately warm and humid and in some years temperatures have exceeded 100° for short periods, with the possible exception of a few locations in the higher Appalachian Mountains. Average July temperature is 75°. This varies from 70° to 80° from the northeastern to the southwestern parts of the Basin and with changes in elevation. Extreme maximum temperatures have been 111°. Winters are reasonably cold with an annual average of several days of sub-zero temperatures. Lowest recorded readings have been near 30° below zero. January averages range from 40° to 26° from the most southern to most northern parts, while spring and fall temperatures are most consistent. The annual average, January and July temperatures and extremes of record, and average dates of killing frosts for selected stations are on Table 4. The annual variation in temperature for nine locations in the Basin is on Figure 3. Plates 1a and 1b present isotherms of the mean daily maximum and minimum temperatures for January and July. Although the area exhibits a degree of homogenity in climate, very hot and sub-zero temperatures often occur in the same year. Similarly, severe droughts and floods have been recorded in the same 12-month period. There have also been local droughts in various parts of the Basin but in different years. Flood occurrences vary, seldom covering the entire Basin during the same climatic period.

7. Frost Periods. Last killing frosts occur on the average from April 10 in the southernmost part of the Cumberland Basin in Tennessee to May 30 in the headwaters of the Allegheny. First frosts happen from September 30 in the Allegheny Basin to October 20 in the Cumberland. Killing frost has been noted as early as August 13 at Franklin, Pa., and October 2 at Clarksville, Tenn., and as late as June 12 in the former and May 1 in the latter. Annual frost-free periods or growing seasons are shown on Plate 2. The average growing season varies from 200 days in the south to 120 in the northeast part of the Basin; although extremes have varied from 247 in the former to 73 in the latter.

8. Ice Depth and Duration of Cover on Streams. Ice occurs on all streams in the Basin, varying in thickness and duration, dependent on location, exposure, stream flow and length of cold spell. Ice thickness during the severe January, 1963, freeze on the Ohio River was six to eight inches, with overriding sheets freezing to form flows several feet thick. On tributaries ice more than 18 inches has formed. Ice on the Ohio main stem occurs more frequently in the upper reaches, the stream seldom freezing over for its full length. Running ice may interfere with navigation.

HIGHEST, MEAN, AND LOWEST MONTHLY AVERAGE TEMPERATURE AND AVERAGE PRECIPITATION FOR SELECTED OHIO RIVER BASIN STATIONS

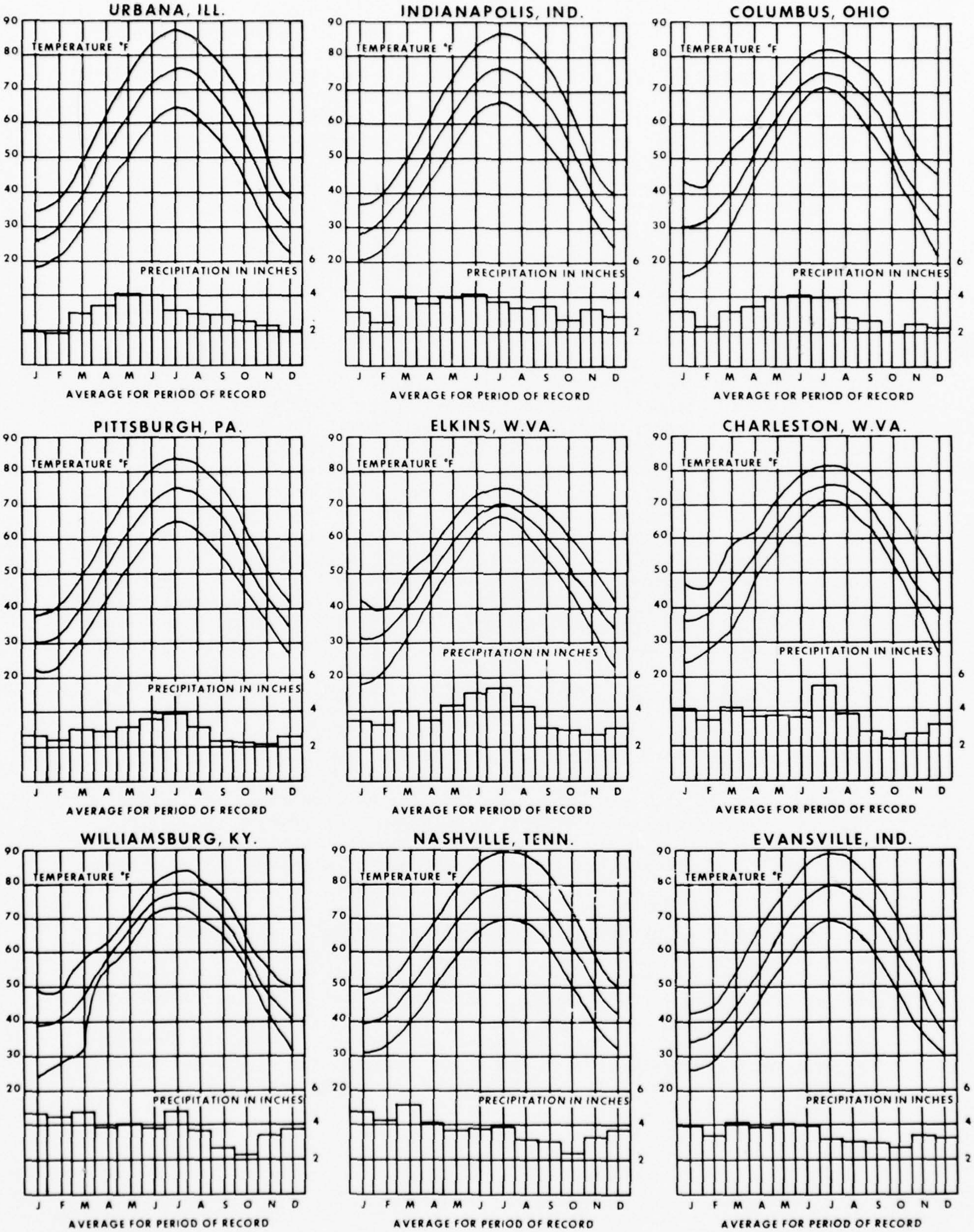


FIGURE 3

Based on available information, dating from 1899, ice has not interferred with navigation earlier than December 9 or later than March 10. Eighty percent of the suspensions to the navigation below Huntington have occurred between January 10 and February 20. Above that city, 70 percent have been noted in that period.

Estimates of frequency of suspensions due to ice since the Ohio River was canalized are shown in Table 3. With completion of the new navigation dams, designed with several submergible gates to pass ice and floating debris, and the more powerful towboats operating on the Ohio, these periods should be reduced.

9. Evaporation. Evaporation and transpiration are important to low flow runoff characteristics and depletion of water in storage in reservoirs and ground water aquifers. Plate 3 shows lines of average annual lake evaporation in inches and percentages likely to occur in the Ohio Basin from May to October. It varies from 28 to 36 inches and 70 to 80 percent.

10. Wind. Prevailing winds with velocities, averaging six to 12 miles an hour, are generally from a south or southwesterly direction on the plateaus, but usually originate in a more westerly direction in the mountains. Winds with velocities more than 50 miles an hour have occurred in all months from each direction except east. Maximum winds have exceeded 80 miles. Damage from hurricanes is uncommon as only the eastern portion of the Basin is exposed. An average of six tornadoes a year strike Indiana, Kentucky and Tennessee, and half that number the eastern states of the Basin. High winds may also be associated with thunderstorms or the intense large area storms. These occur on the average of 30 times a year in Pennsylvania and 50 times in Kentucky and Tennessee. Direction and average velocity for the prevailing and monthly winds for four locations in the Basin are on Plate 4.

11. Precipitation.

a. Mean Annual. Precipitation, including snowfall, varies considerably as to location and year to year. The annual average for the Ohio River Basin is 44.8 inches. It varies from 52 in the southwest section to 56 in the southeast, and 36 along the northern divide. It may be as much as 80 at isolated points of higher elevation in the Allegheny Mountains.

b. Maximum and Minimum Annual. Extreme years of precipitation at first order climatological stations have varied from 20 inches in 1930 at Parkersburg to 72 at Paducah in 1927. Table 4 presents, for selected stations, the average annual, maximum and minimum month, the annual extremes of record and the year of occurrence. Plate 5 presents isohyets of average annual precipitation. Plate 6 shows annual precipitation for a 75-year or longer period at Pittsburgh, Columbus, Urbana, Ill., and Nashville.

c. Monthly Distribution. The average monthly distribution of rainfall for selected locations is on Figure 3. Greatest precipitation

ANNUAL PRECIPITATION FOR SELECTED OHIO RIVER BASIN STATIONS

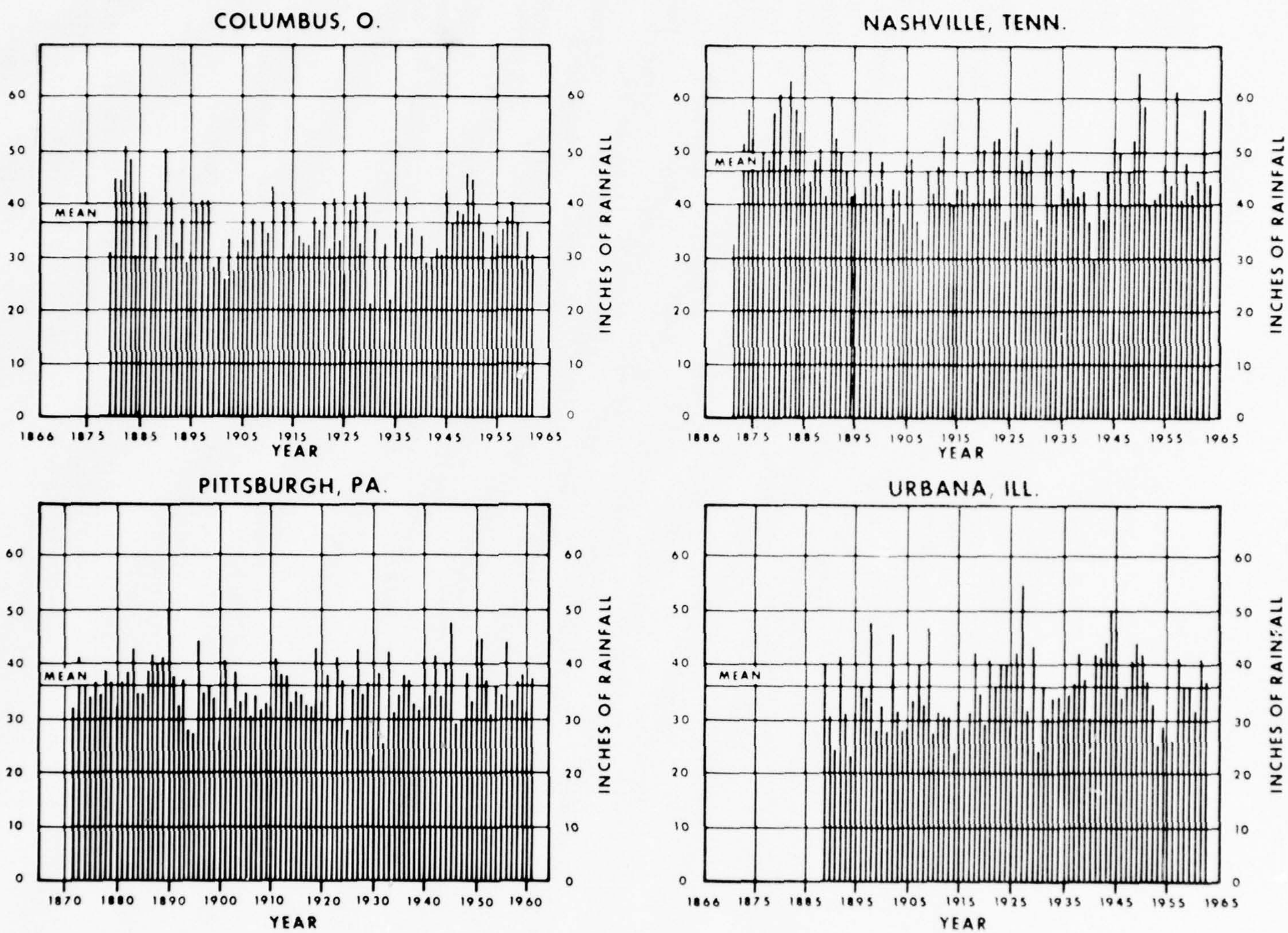


FIGURE 4

occurs in June or July and the least in October, with some minor modifications due to elevations and location.

d. Intensity-Duration Frequency. Area-depth-duration curves have been developed for various storms. The average intensity of rainfall over an area varies as to its size being greatest at a particular point and lowest for the total area. An area-depth curve in Weather Bureau Technical Paper 29, Part 3, for areas up to 400 square miles, may be used together with point rainfall intensity-frequency data to estimate precipitation on them.

Point rainfall may be determined from maps in Weather Bureau Technical Papers 40 and 49, Rainfall Frequency Atlas of the United States, for durations from 30 minutes to 10 days and return periods from one to 100 years. There are also maps in Technical Paper 40 indicating Probable Maximum Precipitation. These curves for four locations in the Ohio Basin are presented on Plate 7. For larger areas, characteristic storm patterns based on historical records are used to determine rainfall distribution and intensity for climatological studies related to flood control projects.

The Soil Conservation Service uses generalized rainfall data for upstream areas where historical data are not available. Soil Conservation Service National Engineering Memorandum 27 (Rev.) dated March 19, 1965, sets forth the limiting criteria for the development of emergency spillway and freeboard hydrographs. Curves on Plates 8 and 9 taken from data in the memorandum show point rainfall to area rainfall correction factors versus drainage area and rainfall distribution for the six-hour storm.

e. Snow. Snowfalls in the Basin may be heavy, but are usually followed by thawing periods and there is no large scale melting in the spring. Nevertheless, heavy rains falling on snow have caused floods in the Basin. Average annual snowfall varies from eight inches in Nashville to 95 at Jamestown, N.Y. Plate 10 shows average annual Basin snowfall. Table 4 gives snowfall for selected locations.

f. Drought Periods and Descriptions. Precipitation is generally sufficient for agriculture, but occasionally soil moisture deficiencies cause vegetation to wilt. This may be due to lack of precipitation, excessive evaporation caused by high temperature and dry winds or untimely distribution of a normally sufficient amount of rain.

Droughts are usually local in nature and crops are seldom ruined, but an economic loss may occur, due to reduction in yield. The potential evaporation and transpiration often exceed precipitation in the growing season, so peak demand for supplementary irrigation normally occurs July 1 to August 15.

Major droughts in the Ohio Basin have occurred in 1894, 1895, 1901, 1914, 1930, 1934, 1936, 1941, and 1953, and the recent drought which started in 1962 and has continued through 1965. The severest basin-wide drought of the 20th Century was in 1930. Based on available data, the worst year was in 1895. These drought periods result in low stream flow. This is discussed in Paragraph 17, Drought Flows, this appendix.

The recent major droughts are described here:

(1) 1930. Annual precipitation was deficient in all states, varying from 10 to 18 inches below the state averages and the lowest of record in many. Temperatures averaged 10° above normal and readings above 105° were recorded in all states. The rainfall deficiency began in February and continued through September, causing crop failures. Stream flow was low, wells went dry and water was scarce for all purposes.

(2) 1934. As the result of an abnormally hot summer, and unfavorable distribution of rain, this drought was severe. Ohio had its driest year of record and Indiana its second driest. The drought was significant because it was the fifth consecutive year of above normal temperatures and subnormal rainfall. Unprecedented dust storms occurred over a large part of the Basin and many previously dependable wells failed.

(3) 1936. This was one of the most severe during a growing season. Although average temperatures and precipitation were only slightly abnormal, the warm dry period from May to July resulted in major crop damage. In many states, the May and June precipitation was the lowest of record, and July and August were very hot with frequent irregular thunderstorms.

(4) 1941. The drought came in the early months causing failure of spring crops. Many of the later crops were saved by heavy but erratic rains in June, July and August. In Tennessee, this was the driest year of record and there were many forest fires in West Virginia. Although many crops were spared, wells and streams were very low by September, October rains breaking the dry spell.

(5) 1953. This drought began in June and continued through November. The beginning of the year was warmer than normal and from May on was also unusually warm and dry, resulting in fall crop damage in many areas. Rivers and reservoirs continued low into December and many wells failed. Serious forest fires were reported from September through November.

(6) 1962. Runoff for the year was below normal in a wide band extending from the northern portion of the Allegheny River Basin into northeastern Ohio. Rainfall in September somewhat alleviated the drought conditions that had been developing in this area. Temperatures and ground water levels throughout the Ohio River Basin were for the most part, near normal.

(7) 1963. Precipitation at seven representative climatological stations scattered throughout the Basin were below means of record.

Of these, Evansville, Indiana, showed the greatest departure from the mean, approximately 13.5 inches. Major crop damage was prevalent throughout the Basin. Temperatures were near normal. Groundwater levels reached new record lows along the Pennsylvania-New York boundary and extending southwestward into Ohio. In some portions of Kentucky, September marked the start of a serious drought which lasted through February of the following year.

(8) 1964. Precipitation and streamflow were again below normals throughout the Basin, but generally above the 1963 values. Severe agricultural droughts occurred (rainfall in some areas during the summer was spotty). Groundwater levels continued at record lows.

(9) 1965. Drought conditions persisted, with streamflow and groundwater levels continuing below normal. Some streams in the Basin reached record lows, partly as a result of a carryover of groundwater deficiency from the previous year. Wells and reservoirs for many small communities went dry.

g. Humidity and Fog Conditions. Because of varied topography and associated differences in local climates, generalized statements for humidity conditions in the Basin cannot be made, with the exception that it is usually highest in the early morning hours and lowest shortly after noon. Occasional nocturnal and morning fogs occur in river bottoms in late summer and autumn, but may also happen in the spring. Low clouds and fog in the mountains are generally the result of moist winds moving up slope. These fogs may happen at any time and there is usually a marked difference in such conditions on opposite sides of ridges. Relative humidity at four selected stations is given in Table 5.

12. Storms. Several types of storms occur in the Basin. One is characterized by long duration, relatively low intensity and wide extent, during which an enormous amount of water falls. The weather systems which result in these widespread flood-producing storms originate by the opposing action of two large stationary anticyclones - "highs" - one located off the Atlantic coast and the other entrenched over the upper portions of the Mississippi and Missouri Basins, or possibly north of the Canadian Border. These produce a more or less stationary front which lies northeast to southwest across the Basin. Along this front a succession of "moist waves" may move northeastward resulting in bursts of copious warm rains for prolonged periods. The condition continues to exist until there is a displacement of one or both of the anticyclones. Meteorological conditions such as these are confined to the winter or early spring months. The floods of January, 1913; January, 1937; and March, 1964, were produced by this type of storm.

Another type causes moderate to fairly heavy, and sometimes intense, precipitation for a period generally not exceeding five days, over broad but smaller areas. These involve one or more closely related cyclones - "lows" - and occur most frequently from December to April when soils are generally saturated. Such storms produced the floods of February, 1884; March, 1913; and March, 1936. They occasionally occur during the summer, but since the soil is able to absorb a great quantity of rainfall, runoff is less. A more detailed discussion of storms may be found in Hydrometeorological Report No. 38, of the U.S. Weather Bureau, Meteorology of Flood Producing Storms in the Ohio River Basin.

A study of past flood producing storms indicates that the general northeast-southwest alignment would continue. However, the storm center with heaviest rains could be transposed to almost any point in the Basin, still distribution of rainfall would be affected by topographic features. Moderate rainfalls can occur on the perimeter of each storm.

Storms covering areas from 50,000 to 200,000 square miles may result in up to 15 inches of rainfall during a two- to five-day period within this area and storm period. Areas as large as 20,000 square miles may experience 24-hour rainfalls in excess of six inches. The Basin may experience several of these two-to five-day storms in succession, separated by only three or four days of clear weather.

Hurricanes from June through October may affect the area of the Ohio River Basin closest to the eastern seaboard. Accompanying intense rains may extend into the Allegheny Mountains but rarely spill over into the Ohio Basin. Since 1900, only three destructive tropical storms have entered the area. The Monongahela Basin October, 1954, floods were caused in this way.

Thunderstorms often yield intense local rainfall and may cause flash flooding on small streams. The Ohio Basin averages 30 to 50 days of thunderstorms each year, only a few severe. An example of an extremely rare intense local rainfall due to such storms was a deluge of 19 inches in 130 minutes at Rockport, W. Va., July 18, 1889. It is extremely difficult to give advance warning of this type downpour for a specific area.

Major widespread storms of record are the ones of March, 1913; March, 1936; and January, 1937. Isohyetal maps and depth duration charts for the March, 1913, and January, 1937, storms are shown on Plates 35 and 36. The flood of January-February, 1937, was the most destructive the Ohio Basin has experienced. An unusual combination of meteorological conditions beginning in December, 1936, caused excessive and almost continuous rainfall January 6-25, with highest intensities January 20-25, centered largely in the middle and lower portions of the Ohio Basin. The 20-day rainfall was the greatest and most prolonged recorded in the Basin, exceeding 22 inches at several stations in the lower Tennessee, Cumberland and Green River Basins. The rainfall averaged 10 inches over the entire Ohio Basin with five in the last five days of the storm.

The 1913 storm centered over the Great Miami River Basin and caused severe flooding in the Wabash, Miami and Scioto River Basins. The ground was saturated by two periods of precipitation, March 14, and March 19-20, but these disturbances passed rapidly eastward. Early March 23, a high-pressure system appeared over the Rocky Mountains and Great Plains and began moving rapidly eastward until its main center was over the Great Lakes the following morning. A storm area also developed over the southwestern states forming a long tongue of low pressure which enveloped the Ohio River Basin for 60 hours or more. The stationary front caused the overflowing warm air to release large quantities of rain. The main centers of precipitation developed at Richmond, Ind., and Bellefontaine, Ohio, where the downpour was more than 11 inches in each case for March 23-27.

The March, 1936, storm period is unique in that a slight change in climatic circumstances could have produced larger inundation. The winter of 1935-36 was unusually severe in the upper Ohio Basin; temperatures were below and snow precipitation above normal. A thaw beginning February 23 depleted much of the snow cover by the end of the month. The rise in streams broke up the unusually thick channel ice. However, there was still considerable snow with three to five inches of water content on the western slopes of the Allegheny Mountains.

A well developed low pressure system moved northerly across the area, March 11-12, with warm light rains averaging one to two inches. The same amount of snow melt added to the Youghiogheny River flow and flooded the Clarion River. Maximum discharge occurred on some tributary streams. A second storm system, March 17-18, caused by a stationary low pressure trough, between a North Atlantic or Bermuda high and a continental high, produced snow in the Monongahela Basin and northern part of the Allegheny Basin. But in the area to the south of the Clarion River, six-inch rains on the western slopes of the Allegheny Mountains were supplemented by melting snow and major flood peaks resulted.

In some parts of the Allegheny and Monongahela Basins, the March 17-18 snowfall added to snow on the ground and later rains resulted in a third peak in particular areas from March 22-26. Additional general flooding outside this area did not result.

The March, 1964, storm resulted in the sixth highest flood of record at Cincinnati, and the biggest on the river since March, 1945. It was caused by two storms that moved eastward over the Basin. The first, March 3-5, dropped eight inches of rain at Paducah, six at Louisville and four at Cincinnati. In many areas the Ohio River approached flood stage. The second storm, March 8-10, caused even heavier rains and, combined with the previous downpour, produced 16 inches at the mouth of the Cumberland River, 13 at Louisville, 10 at Cincinnati and two at Huntington. Alignment of the maximum rainfall was northeast-southwest, with the center slightly below the Ohio River, along a line from the mouth of the Cumberland to Louisville.

13. Hydroclimatic Data Gathering Program.

a. Data Sources. The U.S. Weather Bureau is the principal agency engaged in collecting and compiling climatological data. Other Federal agencies and local government units cooperate in furnishing funds, observers and gaging locations. Information is also collected by individuals, industries and institutions and may be sent to the Weather Bureau for record. Pertinent data are published in Climatological Reports. The Weather Bureau also has the responsibility for weather and flood forecasting and in some cases makes predictions of low flows.

b. Available Data. Information available relates to precipitation, temperature, wind, humidity, cloud cover, evaporation, and the like. The reliability varies as to the type of equipment at the stations, continuous, hourly or daily readings and length of record. The Weather Bureau has prepared maps showing averages for various climatological U.S. statistics. These are available as sheets of the National Atlas. The Ohio Basin portion of some of these maps is shown on Plates 1a and 1b, 2, 3, 5 and 10. The Atlas and other publications containing climatological data are for sale by the Superintendent of Documents, Government Printing Office, Washington, D.C.

c. Number and Type of Stations and Length of Record. The Ohio Basin is covered by a network of 900 official climatological and/or hydroclimatic stations operated by the Weather Bureau. Three hundred and six have continuous recording precipitation gages, charts of which are attended once a day or oftener. The others use standard non-recording gages, some of which are read more than once daily. Many stations have more than 60 years of record. Table 6 lists the number of precipitation and temperature stations in each sub-basin.

The map on Figure 5 locates climatological stations for which data are presented in this report. Locations are shown on maps prepared by the Weather Bureau in 1960. They are available from the Government Printing Office.

Table 4 presents climatological data for 22 stations in or adjacent to the Basin. Record keeping started in 1871 at a few stations.

d. Hydroclimatic Network. Some of the referenced stations are part of a nationwide setup operated and administered by the Weather Bureau at the request of the U.S. Army Corps of Engineers. These provide data to meet Corps requirements and supplement the regular Weather Bureau network of meteorological stations. In 1964 there were approximately 225 under this program in the Basin of which 215 have recording gages. The Weather Bureau publishes recorded information in its Hourly Precipitation Data. The non-recording material is carried in its Climatological Data.

CLIMATOLOGICAL STATIONS
OHIO RIVER BASIN
AS LISTED IN TABLE 4

STATION LEGEND

◪ TEMPERATURE, PRECIPITATION

■ TEMPERATURE, PRECIPITATION, (SNOWFALL)

FIGURE 5

SECTION IV - HYDROLOGY

14. Hydrologic Data Gathering Program.

a. Agencies Involved. The U.S. Geological Survey is the agency primarily responsible for the collection and tabulation of surface and ground water data. Certain general ground water information is covered in Appendix E, Ground Water in the Ohio Basin. The records of discharge and contents of lakes and reservoirs in the Nation are published by the U.S. Geological Survey, under a cooperative program with other U.S. agencies, states and local interests and private industries assisting and sharing in expenses. Every state in the Ohio Basin is a participant. Other organizations involved are the Department of the Army, Air Force, Tennessee Valley Authority, Atomic Energy Commission, the Department of Agriculture's Soil Conservation Service, Forest Service, and Agricultural Research Service and the Department of Commerce. The agencies cooperate in obtaining data at specific project locations which are necessary to their work but beyond the scope of the normal U.S. Geological Survey operations. U.S.D.A. stations making hydrologic studies on upstream areas in the Ohio River Basin are located at Coshocton and New Philadelphia, Ohio and Berea, Kentucky.

Water quality is covered in the report of the U.S. Public Health Service, Appendix D. Suspended sediments are discussed in this appendix, Section V, Sedimentation.

b. Data Available. Daily discharge data are published for 540 gaging stations in the study area. Surface Water Supply of the United States 1959, Part 3A, Ohio River Basin Except Cumberland and Tennessee River Basins, gives information for 472 tributary and 13 main stem stations. An additional 55 in the Cumberland Basin are reported in Part 3B, Cumberland and Tennessee River Basins. Augmenting these are limited discharge measurements made during floods or low flow periods at miscellaneous sites. The latest basin-wide publications used for this study are the 1959 Water Supply Papers 1625 and 1626 available from the Government Printing Office. This information is now being published on a state basis and reports will be issued as soon after the end of the water year as practical. The U.S.G.S. Water Supply Papers will be published at five-year intervals.

While the U.S. Geological Survey began studying stream discharge in the Ohio Basin in 1888, only eight percent of the station records are for periods longer than 39 years. The majority are from 10 to 30 years and are for observed flows. Electronic computer analyses are available for most stations in Indiana, Kentucky, Maryland, Virginia, West Virginia, Pennsylvania and North Carolina, and some in Tennessee and Illinois. These "print-outs" for each year give number of days that the daily discharge was between selected limits (duration tables) and for lowest and highest mean discharges for selected numbers of consecutive days in each year ranging between one day and 274 days. Frequency computations are also available at some stations.

State water inventories and reports also develop records on flow duration, frequency and low flow storage requirements based on U.S.G.S. reports. Information for specific project studies may also be available from the Corps of Engineers, T.V.A., Weather Bureau, S.C.S., U.S.G.S., individual state agencies, cities, municipal authorities and private power companies and industry.

The Weather Bureau's Daily River Stages contains information for those key stations used in flood predictions. These records date from 1858, and, for the recent years, are available from the Government Printing Office. The publication gives station location, length of record, elevation of gage zero above mean sea level, distance of gage above mouth of river, drainage area above the gage, flood stage and extreme high and low stages and dates. For the year of publication it also has the daily stage readings at each gage. The 1958 edition lists 41 gages on the Ohio River and 108 on tributaries, excluding the Tennessee River. Some of these gages on the Ohio were located at the old navigation locks and dams which are being replaced by a fewer number of high lift structures.

Some of the more pertinent U.S.D.A. data available on upstream areas are as follows:

(1) Monthly precipitation and runoff for small agricultural watersheds in the U.S., 1957.

(2) Annual maximum flows from small agricultural watersheds in the U.S., 1958.

(3) Selected runoff events for small agricultural watersheds in the U.S., 1960.

c. Stream Gaging Stations. The number of rated discharge stations in each major tributary and the distribution of the length of the record based on Water Supply Papers 1625 and 1626 is shown in Table 7. The earliest records for discharge is 1877 at Kanawha Falls, on the Kanawha River, and for continuous stage, 1857 at Cincinnati.

Rating curves for each gage location are available from the U.S.G.S. This agency under contract to the Corps of Engineers has extended the rating curves at 12 key stations on the main stem Ohio and at 70 principal stations on tributaries as part of the Ohio River Basin Comprehensive Study.

d. Location of Stations. Locations of all stream gaging stations in the Ohio Basin and type of gage, whether rated stage only, recording, or non-recording, are shown on maps prepared in 1960 by the Inter-Agency Committee on Water Resources. Five cover the entire Ohio Basin and are available from the Government Printing Office. They are:

(1) No. 17 - Ohio River Basin - Madison to Uniontown - Wabash River Basin.

(2) No. 18 - Tennessee River Basin below Hales Bar - Cumberland and Green River Basins.

(3) No. 19 - Ohio River Basin - Pt. Pleasant to Madison - Kanawha to Kentucky Basin - Scioto to Miami Basin.

(4) No. 20 - Tennessee River above Hales Bar.

(5) No. 21 - Ohio River above Pt. Pleasant and Lake Erie Drainage.

Locations for stream gaging stations referred to in the Table Flow of Selected Streams - Ohio River Basin are shown on Plates 11a through 11d.

e. Frequency Determinations. The basic frequency curve used in hydrologic engineering is the frequency curve of annual maximum or annual minimum events. The two basic approaches to estimating frequency curves are graphical and analytical. Since the "Guidelines for Framework Studies" as set forth by the Interdepartmental Staff Committee, Water Resources Council, require the use of existing data, the sources of frequency data included the U.S.G.S., S.C.S., Corps, Miami Conservancy District and various state reports. Therefore, the frequency data as contained in this appendix were developed by various graphical and analytical methods.

Frequency data for the Ohio River were supplied by the Corps' Ohio River Division Office. Natural maximum annual frequency curves were developed by the Corps in accordance to the method in papers by Leo R. Beard, Statistical Methods in Hydrology, Office of the Chief of Engineers, U.S. Army, July, 1952, and U.S. Army Engineer District, Sacramento, January, 1962. The following assumptions and qualifications are specified:

(1) Annual maximum flows when expressed as a logarithmic series can be fitted to Pearson Type III curves (the "normal distribution" curve is a special case with zero skew).

(2) Fitting of the curves from the derived statistics (mean, standard deviation and skew coefficient) of a series of events by moments is possible as described by H. Alden Foster (A.S.C.E. Transactions, Vol. 87, 1924, p. 142).

(3) Each value of the series is independent of the others and is obtained under the same general conditions. This consideration is quite important when developing natural frequency curves from basic data in which flows have been modified by reservoir regulation. It is essential that all modified flows be restored to natural conditions.

For the Ohio River natural flood frequency computations, the observed peak annual flows for all years since initiation of storage were adjusted to natural conditions by evaluating actual reservoir effects existing at that particular time. The computed natural statistics (mean, standard deviation, coefficient of skew) for the entire period of record were then adjusted by reconciling adjacent points and comparison on drainage area proportions, to produce consistent statistics throughout the length of the main stem. Stage frequency curves were developed by converting flows to stage through the use of crest stage-maximum discharge relationships plotted from historical data, and extended rating curves prepared in connection with the Ohio River Standard Project Flood study.

To determine modified flood peaks on the Ohio River, 12 historical floods, plus three hypothetical ones of greater magnitude, were used in the analyses of flow modification. The flows for these 15, considered representative of the Basin, were modified by the operation of Corps of Engineers' reservoirs, completed, under construction, or in preconstruction planning as of July 1, 1963, shown on Figure 6. The amount of reduction in peak discharge versus the natural one for the foregoing inundations were used to develop curves indicating average reservoir system capability to reduce floods. Values from the curves thus obtained, when applied to the natural peak flows for various recurrence intervals, positioned the modified discharge frequency curve.

The low flow frequency analysis for the Ohio River was obtained by similar method applied to low flows, except a standard skew coefficient was used for natural main stem 30-day low flow frequency computations.

Frequency data for each of the tributary sub-basins was obtained from the U.S.G.S., S.C.S., Miami Conservancy District and various state reports. Low flow frequency data obtained from the U.S.G.S. are determined for the annual series by the formula $T = \frac{n+1}{m}$, where T is the recurrence interval in years, n the number of years of record, and m the order number of the event with the lowest event in the array being order number 1. These points are then plotted on a special form of arithmetical probability paper with discharge on a linear scale as the ordinate, and recurrence interval in years or percent chance of occurrence on a scale graduated to the theory of extreme values (Gumbel, 1941) as abscissa. A curve is then fitted to the plotted points.

Methods used to estimate the frequency of events by the Soil Conservation Service such as flood peaks, are found in that agency's National Engineering Handbook (NEH) 4, Hydrology, Supplement A. Two types of frequency series are used, the annual taking only the largest value in each year, and the partial duration, utilizing all the values equal to or above an arbitrary base, usually the lowest annual series value. In general, the annual series are used. This method of analysis considers only the largest flood event for each water year (October through September). The events are arrayed in descending order of Magnitude with the largest having a rank number of 1. Logarithmic normal probability paper, also called log-normal or Hazen paper, is used to plot the data. The plotting positions are computed using the Hazen equation $Fa = \frac{100(2n-1)}{2y}$, where Fa is the plotting position in percent, n the rank number and y the number of years of record. The log-normal or Hazen paper has a three-cycle logarithmic scale for the data and both percent chance and standard deviation scales for

OHIO RIVER BASIN
CORPS OF ENGINEERS RESERVOIRS

COMPLETED, UNDER CONSTRUCTION, OR IN ADVANCED PLANNING

JULY 1963

LEGEND

OHIO RIVER BASIN BOUNDARY (EXCLUDING TENNESSEE RIVER BASIN)

STATE BOUNDARY

RESERVOIR STATUS

EXISTING RESERVOIRS

RESERVOIRS UNDER CONSTRUCTION

RESERVOIRS UNDER ADVANCED PLANNING

ALLEGHENY RIVER BASIN
1-ALLEGHENY
2-UNION CITY
3-TIONESTA
4-EAST BRANCH CLARION
5-MAHONING
6-CROOKED CREEK
7-CONEMAUGH
8-LOYALHANNA

MONONGAHELA RIVER BASIN
9-YOUGHIOGHENY
10-TYGART

BEAVER RIVER BASIN
11-SHENANGO
12-MOSQUITO CREEK
13-WEST BRANCH
14-BERLIN

MUSKINGUM RIVER BASIN
15-BOLIVAR
16-ATWOOD
17-LEESVILLE
18-DOVER
19-TAPPAN
20-CLENDENING
21-PIEDMONT
22-SENECAVILLE
23-WILLS CREEK
24-BEACH CITY
25-MOHICANSVILLE
26-CHARLES MILL
27-PLEASANT HILL
28-MOHAWK
29-DILLON

HOCKING RIVER BASIN
30-TOM JENKINS

KANAWHA RIVER BASIN
31-SUTTON
32-SUMMERSVILLE
33-BLUESTONE

TWELVEPOLE CREEK BASIN
34-EAST LYNN

BIG SANDY RIVER BASIN
35-DEWEY
36-FISHTRAP
37-JOHN W. FLANNAGAN
38-NORTH FORK

LITTLE SANDY RIVER BASIN
39-GRAYSON

SCIOTO RIVER BASIN
40-PAINT CREEK
41-DEER CREEK
42-BIG DARBY
43-DELAWARE

LITTLE MIAMI RIVER BASIN
44-CAESAR CREEK
45-EAST FORK

LICKING RIVER BASIN
46-CAVE RUN

MILL CREEK BASIN
47-WEST FORK

GREAT MIAMI RIVER BASIN
48-BUCK CREEK
49-BROOKVILLE

KENTUCKY RIVER BASIN
50-BUCKHORN

CUMBERLAND RIVER BASIN
51-LAUREL
52-WOLF CREEK
53-DALE HOLLOW
54-CENTER HILL
55-J. PERCY PRIEST
56-BARKLEY

GREEN RIVER BASIN
57-BARREN RIVER
58-GREEN RIVER
59-NOLIN
60-ROUGH RIVER

WABASH RIVER BASIN
61-MONROE
62-CAGLES MILL
63-MANSFIELD
64-MISSISSINEWA
65-SALAMONIE
66-HUNTINGTON

FIGURE 6

the normal distribution. This extends at least three standard deviations, plus and minus, from the mean. Discharge is plotted on the logarithmic scale as the ordinate and percent chance of occurrence as the abscissa. The logarithms of the magnitude of the events are used to calculate a line, or a line of best fit is drawn through the points with less weight given to those that plot far off the line.

Frequency analyses of peak discharge and runoff volume data are also accomplished by means of a computer program prepared by the Central Technical Unit of the Soil Conservation Service, Washington, D.C. This program utilizes, primarily, the two parameter gamma distribution for computing the 0-99 percent chance events and the log-normal distribution whenever the gamma statistic is greater than 51.

If information was not available from U.S.G.S. or Corps Districts frequency of low flows in tributaries was developed from U.S.G.S. Water Supply Papers. For derived data, observed flows were restored to natural conditions. The average discharge for the lowest consecutive seven days for each year of record was placed in the order of magnitude and the distribution determined by graphical means. Frequency curves were developed by Beard's method. Because the curves represent cumulative frequencies in descending order of flow magnitude, the probability scale gives the percent chance that an annual event will be equaled or exceeded, and is sometimes designated "exceedence frequency". This annual series method of frequency analysis does not consider more than one low flow period each year or seasonal distribution of discharge. The basic statistics, the mean (m) and the standard deviation (s), were computed by the Corps analytically for each individual gaging station. However, a standard skew coefficient was used for the entire Ohio Basin tributary streams. From these computed data, straight line frequency curves were drawn on log probability paper with slopes equal to the standard deviations and with means at 50 percent probability.

A variety of methods has been proposed for determining frequencies, but none are completely satisfactory for the rare occurrence. Plotting position methods tend to assign too much weight to the rare event occurrence in a short period and are largely dependent on the record length. Statistical analysis such as Beard's tends to rely heavily on the bulk of the midrange events in the estimation of the population parameters, and has the effect of assigning low occurrence chance to rarer events. The use of the plotting papers made up in special graphs such as the Gumbel Theory of Extreme Values, purports by a pre-arranged distortion of the probability scale to distribute the extreme values more closely to positions they might be expected to occupy in a more complete frequency array.

It must be recognized that statistical methods are based on the data available and all assume that the same general events will be repeated. Various methods may give different results. Therefore, the frequency data contained in this appendix are to be considered only as guides. For the design of specific water resources projects, detailed frequency studies should be made.

15. Runoff.

a. Average Annual. Average annual runoff for major tributaries of the Ohio Basin varies from 11 to 23 inches. The average for the Ohio at the lowermost gaging station, where there is a drainage area of 203,000 square miles, is 17.3 inches or 187 million acre feet. This gage is located at Metropolis, Ill., and is 37 miles upstream of the mouth and nine and one-half below the Tennessee River. The maximum annual runoff of 29.7 inches occurred in 1950 and the minimum of eight in 1941.

Mean annual runoff from the Allegheny and Monongahela Basins is more than 23 inches, between 58 and 60 percent of the average precipitation; whereas in the Wabash Basin the runoff is 12.8 inches or about 31 percent. The average annual runoff for tributary branches varies considerably. For example, in the Monongahela Basin, that from small streams has been greater than 32 inches and in the Wabash Basin less than 11. Figure 7 shows the average, maximum, and minimum annual runoff in inches for major tributaries of the Ohio Basin.

Table 8 presents the mean annual discharge and the discharge for the year of record in cfs and inches at the key gaging station in each sub-basin.

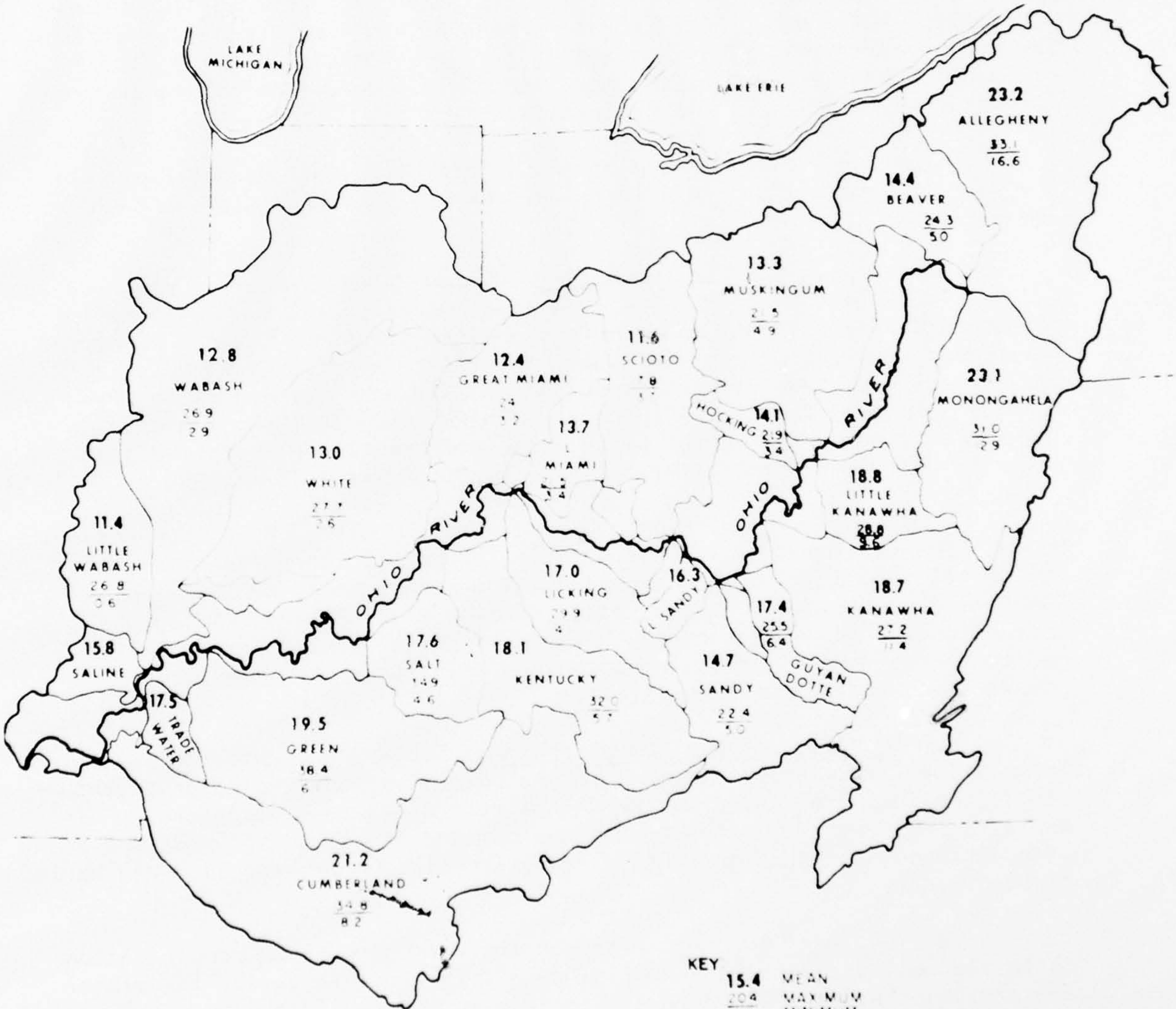
Throughout most of the Basin, 1950 was a water year of high average runoff. Low years were 1941 and 1954 in the tributaries. Variations in climatological conditions and runoff characteristics may cause the year of maximum or the year of minimum runoff to differ in adjacent basins. The maximum tributary runoff year from 1927 to 1959 was 33.1 inches in 1956 for the Allegheny Basin, while the minimum was 16.6 in 1954. An extreme low annual runoff, six-tenths of an inch, occurred in the Little Wabash Basin in 1931. The highest at the same location was 26.8 in 1950.

The Wabash, Great Miami, Little Miami, Hocking, Muskingum and Beaver River Basins exhibit somewhat similar runoff characteristics, and may be put in one hydrologic grouping. The Green, Salt, Kentucky, Licking, Sandy, Guyandotte, Kanawha and Little Kanawha River Basins fall into another group; the Allegheny and Monongahela River Basins into a third; and the Cumberland River Basin, because of its longer east-westerly orientation, into a class by itself.

b. Maximum and Minimum Discharge. Table 9 presents the following information for selected stations on the Ohio River and the major tributaries: location, drainage area, period of record, average discharge in cfs and acre feet a year, instantaneous maximum and minimum discharges and dates of occurrence, and the consecutive seven-day minimum average flow and period of occurrence.

c. Seasonal Runoff. Although the average monthly precipitation is fairly well distributed annually, runoff is greatest during the winter and early spring months and lowest in late summer and fall. Figure 8 illustrates the monthly mean, minimum and maximum discharges for the period

ANNUAL RUNOFF IN INCHES
OHIO RIVER SUB-BASINS



NOTE: MEAN IS FOR PERIOD OF RECORD, MAX. & MIN. FROM 1927-1959, BOTH AT LOWERMOST GAGING STATION

FIGURE 7

DISTRIBUTION OF MONTHLY MEAN DISCHARGES FOR SELECTED OHIO RIVER BASIN STATIONS

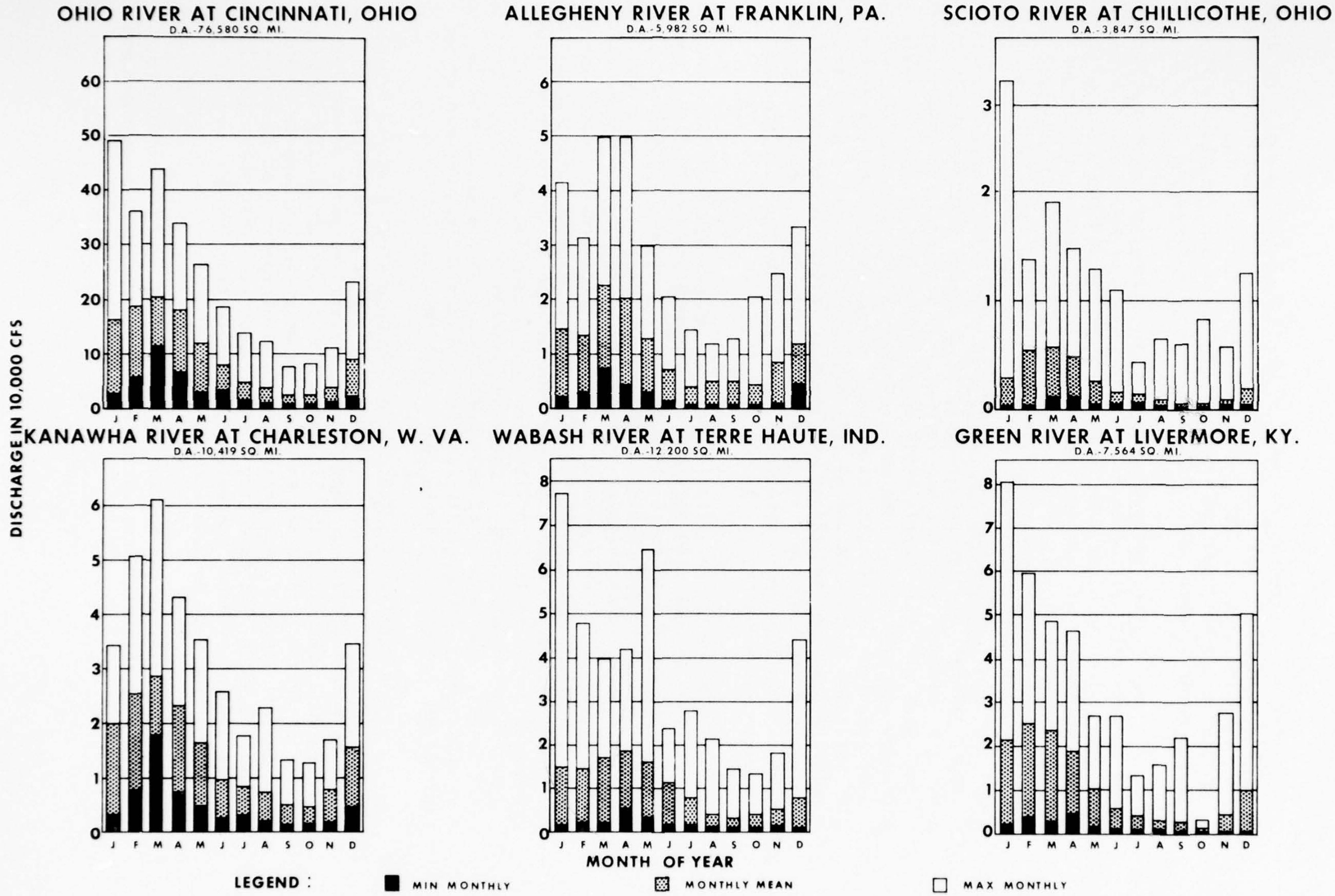


FIGURE 8

of record, of six representative stations in the Ohio Basin. The highest monthly mean runoff has occurred in March or April, dependent on location in the Basin, with the lowest in September or October. The maximum monthly runoff has happened in January or March and the minimum in September or October, also depending on the location.

d. Average Daily Discharge. The hydrographs on Plate 12 show the average daily discharge for the Ohio River at Huntington for 12-month periods, with the highest and lowest instantaneous flow. The vertical scale is logarithmic and therefore distorted. However, the curves illustrate the great variation in seasonal daily discharge on the river and the general similarity between a year of high and low discharges.

e. Infiltration and Base Flows. The ability of a given soil to absorb rainfall applied continuously at an excessive rate rapidly decreases until a fairly uniform minimum rate of infiltration is reached. Infiltration rates will vary considerably depending on location in the Basin, geology and soil types, land use and cover, slope, and the like. At the same location, infiltration rates will change as permeability does because of variation in temperature of soil and rainfall, cover, intensity of rainfall and other antecedent conditions. Initial losses and infiltration rates used for hydrologic analysis are usually determined from reconstruction of rainfall-runoff relationships of past storms. The procedure follows Corps of Engineers EM 1110-2-1405.

The winter infiltration indices in the Ohio Basin vary from .004 to .12 inch an hour with initial losses negligible to .20 inch. Losses during the dry summer and early fall are much higher. With light summer precipitation, almost complete retention of rainfall has occurred. Losses, during intense summer storms after periods of dry weather, have been as high as 0.2 to 0.3 inch an hour. Studies of hydrologic records indicate that infiltration losses of 0.02 to 0.05 inch an hour is a representative minimum value to be used for flood control reports for the Ohio Basin summer storms. Initial infiltration losses used for unit hydrograph analysis of summer storms in Corps survey reports vary from 0.5 inch to 1.2 inches. The details of unit hydrograph analysis are beyond the scope of this report. However, typical infiltration indices for winter and summer are presented in Table 10 for tributary basins.

The infiltration indices for the Ohio River Standard Project Flood (SPF) determinations are shown on Plate 32. The initial loss for the characteristic storms used for SPF analysis ranged from negligible to .20 inch, because of the higher initial saturation due to antecedent rains or frozen ground when these storms occur during January to April. The Central States Forest Experiment Station reports that in studies under way since 1952 extensive areas of concrete frost under good forest cover have never been observed. The infiltration indices used for the SPF vary from 0.01 to 0.05 inch an hour.

Initial losses and infiltration rates used for hydrologic analysis by the Soil Conservation Service for upstream watersheds are based on a study of the soils and land use and treatment classes as illustrated in its National Engineering Handbook. All the major soils in the United States have been classified into four groups, A, B, C and D, with A having the highest infiltration potential and D the lowest. In the hydrologic analysis of a watershed, classifications will be determined. Table 11 is a list of typical soils in the Ohio River Basin with their Hydrologic Soil Group.

The land use and treatment classes are utilized in the preparation of hydrologic soil-cover complexes that in turn aid in estimating direct runoff. Types of land use and treatment are classified on a flood runoff-producing basis. The greater the potential of a given land use or treatment to increase total retention, the lower it is on a flood runoff production scale.

Table 12 combines soil groups and land and treatment classes into hydrologic soil-cover complexes. The numbers show their relative value as direct runoff-producers. The higher the number, the greater the amount of direct runoff to be expected from a storm.

The curve numbers were developed in such manner that initial losses due to interception, infiltration and surface storage were accounted for before runoff began. Direct runoff may then be estimated for a given rainfall by use of Plate 13 for various curve numbers as determined from the soil-cover complex.

Base flow is the discharge in the stream at the time runoff begins, and continuing through the storm period excluding overland runoff. This is composed of the subsurface storm flow that enters streams within a relatively short time after rainfall begins. It also includes ground water normally seeping to the stream before the runoff period, supplemented by discharge from the penetration of infiltration to the water table during the storm. The base flow is added to the overland runoff determined by unit hydrograph computations. This obtains the estimated stream flow for the particular storm being analyzed. For preliminary analysis the base flow is assumed to be the average stream flow during flood conditions other than direct surface runoff.

16. Floods of Record.

a. Seasonal Occurrences. The flood season on the Ohio is from December through April with major ones January through March. However, floods on the tributaries may occur in any month. In order to show the distribution, the highest daily average flood discharges for each month of record were plotted for six typical locations and are shown on Plate 14. It reveals that most major floods on these tributaries occur January through April, with very few widespread ones July through November. However, summer storms with intense rainfall, but of shorter duration, occur on the smaller drainage areas. Thus, spillway design of dams is based on maximum probable storms generally occurring during the summer.

Floods of modern record affecting the main stem Ohio are the ones of March, 1913; March, 1936; January, 1937; March, 1945; and March, 1964. Brief descriptions follow:

(1) The March, 1913, inundation originated in the northern part of the Ohio Basin, particularly in the watersheds of the Beaver, Muskingum, Scioto, Great Miami and Wabash Rivers, where all previous high-water records were exceeded. The southern tributaries contributed no more than moderate flow. Through 1964, the 1913 flood has not been exceeded on the main stem in the reach from New Martinsville, W. Va., to upstream of the mouth of the Kanawha River at Pt. Pleasant. The peak discharge at Pomeroy was 633,000 cfs on March 30. Details of the meteorological events associated with this and the other floods to be discussed are covered in Paragraph 12, Storms of Record, this appendix.

(2) The March, 1936, flood was caused by storms centered largely over the Monongahela and Allegheny River Basins. The rainfall was particularly heavy in the mountainous eastern portions of the Basin. Snowfall on the ground added to the runoff and in some areas for certain periods it was greater than the precipitation. The heavy rains were so timed that flood crests on the Monongahela and Allegheny Rivers arrived almost simultaneously at Pittsburgh, resulting in a record high. Record stages also occurred on the main stem to Dam 14, 20 miles below Wheeling, and 115 below Pittsburgh, 45 miles up the Allegheny to Kittanning, and 23 miles up the Monongahela to Elizabeth.

(3) The flood of January-February, 1937, was the most disastrous ever in the Ohio Basin. Excessive and almost continuous rainfall from January 6-25 caused maximum recorded stages in a 705-mile reach of the Ohio from below the mouth of the Kanawha at Pt. Pleasant, to the mouth of the Ohio at Cairo. This flood interrupted virtually all communications and transportation between the north and south banks for periods of a week to a month. Every highway bridge approach between Marietta and the mouth, a distance of 800 miles, was flooded and closed to traffic with the exception of the Cincinnati Suspension Bridge. There the approaches were raised by an earth and sandbag ramp. Except for the lower reaches of the Cumberland, Green and Kentucky Rivers, this was not the most severe flood on Ohio River tributaries. It produced record stages on the Cumberland for 160 miles upstream, above the present location of Cheatham Dam.

(4) The March, 1945, flood was of major proportion along the entire main stem Ohio, increasing in severity from Pittsburgh to Louisville, where it was the second highest of record. Below there the stages were exceeded by several previous floods. It was not serious on most tributaries, many of which did not exceed flood stage in the upper reaches. The profile Plate 15 illustrates the relative effect of the various floods as related to the maximum flood of record for the main stem of the Ohio. Table 13 lists peak stages at key locations along the

Ohio River for major floods of record. Six reservoirs in operation in the Allegheny and Monongahela Basins reduced the 1945 flood stage at Pittsburgh by 1.8 feet. These and two reservoirs in the Beaver Basin resulted in a 2.3 feet reduction at Wheeling. The 14 reservoirs in the Muskingum Basin reduced flood stages at Marietta 3.0 feet. With the exception of Dale Hollow on the Cumberland and the T.V.A. reservoirs in the Tennessee Basin, there were no additional major flood control reservoirs in 1945 in the Ohio River Basin downstream of the Muskingum. Therefore, the effectiveness of reservoirs on the Ohio flood crest brought a 1.0 foot reduction at Portsmouth, 0.5 foot at Cincinnati and 0.2 foot at Louisville.

(5) The March, 1964, flood was the fourth highest flood in the century at Cincinnati (stage 66.2 feet) and the maximum of record in the Licking and Little Miami Basins. The heavier rains were concentrated in the area along the main stem of the Ohio with rainfall exceeding 16 inches at Paducah and 13 at Louisville. The 39 reservoirs in operation, plus 62 local protection projects, prevented damages of $290 million. The reservoirs are located mostly in upper reaches of tributaries, and heaviest rainfall occurred below them. As a consequence, they were less effective in reducing flood stages than if the rainfall had been more widely distributed.

Many of the large floods on the main stem Ohio have discharges above flood stage continuing for many days. The one in March, 1964, exceeded flood stages at Cincinnati for 11 days. By comparison, also at Cincinnati, the 1937 inundation exceeded the flood stage for 19 days and the one in 1963 for 21 days.

b. Peak Discharges. The peak recorded discharges for selected main stem and tributary stream gaging stations are shown in Table 9. These may not be the maximum floods that have occurred as only those occurring in the period of record are included.

Peak discharge for each square mile of drainage area based on stage discharge records and flood marks of prior high water are shown for the main stem and major tributaries on the log-log graphs on Plates 16 and 17.

c. Flood Frequencies. Frequency curves for 22 locations on the main stem Ohio for both natural and modified discharge and stage are presented on Plates 18a through 18e. The Corps of Engineers offices at Pittsburgh, Huntington, Louisville and Nashville furnished frequency data for the major tributaries in their respective districts. The Soil Conservation Service supplied data for locations in upstream watersheds and the Miami Conservancy District for the Great Miami Basin. These were summarized into Table 14 giving the 100-year, 50-year and two-year chance of occurrence for floods at the selected locations for natural and reservoir-regulated conditions. The natural conditions assume no reservoirs operating. The modified data of the Corps assume that Corps reservoirs completed, under construction or in advanced planning as of July 1, 1963 modify the flood flows. The present and with project data, furnished by the Soil Conservation Service, are from typical watershed projects which are either completed, under construction, authorized for construction or planned.

In the analysis of upstream watersheds by the Soil Conservation Service consideration is given to the present channel capacity and to the degree of protection desired from flooding with future or project conditions. Generally, where agricultural lands are involved a three- to five-year level of protection is provided. That is, the channel will contain within its banks a flood event that has from a 33 to a 20 percent chance of occurrence. Where high value crops are grown or urban areas are involved a higher degree of protection from flooding is usually provided.

Flood and stage frequency curves for eight typical locations on upstream watersheds for "present" and "future" condition discharges and stages are shown in Plates 19a and 19b. S.C.S. watershed planning parties within the Ohio River Basin have provided these data from their respective states. The "present" condition assumes no works of improvement and the "future" condition is a combination of floodwater retarding structures with some channel improvement if needed, or channel improvement only, to provide the desired level of protection.

The data provided by the Soil Conservation Service as shown on Plates 19a and 19b and in Table 14 are typical of the instantaneous peak discharges and stage reductions obtained in Public Law 566 upstream watershed projects in the Ohio River Basin on which work plans have been developed to date. The retarding structures control from three to eight inches of floodwater runoff. The area in a watershed controlled by these structures will vary depending on the topography and control needed to provide the desired level of protection. Usually 30 to 80 percent of the contributing drainage area above the major damage reach is behind structures.

The future peak discharge for the Chippewa Creek, in the Muskingum River Basin, Plate 19b, will be larger than the present discharge for the same frequency. This is due to low structure control and extensive channel improvements which will increase the discharge but will reduce flood heights.

d. Ice Jam Flooding. Flooding caused by ice jams, a rare event, is more of a problem on the tributaries than the main stem Ohio. This may occur at locations where constrictions or other stream characteristics cause ice floes to pile up. The gorging may result in backwater at times of high runoff and aggravate flood conditions. Another danger is concentration of discharge into a small portion of the cross section of the river, causing excessive scour and damage to bridge piers, stream banks, and the like.

Ice conditions may exist from late December to March. Winters with severe ice conditions were 1917-18, 1935-36, 1938-39, 1939-40 and 1962-63.

17. Drought and Low Flows.

a. Seasonal Occurrences. Low flows occur each year as runoff diminishes due to increased losses by evapotranspiration and a change in the rainfall distribution from wide-area to local storms. Ohio Basin runoff is lowest in September or October. However, instantaneous minimums have occurred at various locations in the Basin in all months except March through May.

After surface runoff ceases the entire flow of a stream is drawn from ground water storage. Extended drawdown can deplete this storage unless it is replenished by precipitation.

Knowledge of low flow stream characteristics is required for design of water supplies, waste treatment plants, agricultural and industrial operations, low flow releases and recreation. A prolonged low flow may be more critical than the lowest instantaneous discharge during a given period.

b. Low Flow Periods. Instantaneous low flow for selected gaging stations in the Ohio River Basin are given in Table 9. The minimum discharge recorded at Metropolis, the lowermost gaging station on the Ohio, was 15,000 cfs in July, 1930. However, a minimum discharge of 10,000 cfs was estimated for September 13-15, 1925.

c. Discharges, Relation to Normal Flow. The instantaneous low flows are unrelated to the mean annual discharge. This latter covers many years of record containing annual periods of high and low flows, and has little significance to shorter periods.

d. Low Flow Frequency. The analysis of stream low flow characteristics is necessary in planning for full use of a basin's water potential. The same statistical methods for determining frequency of flood flows are used for low flow frequency analysis and are described in Paragraph 14e. However, the low flow is usually based on a consecutive-day basis when it is less than a specified amount. Low flow frequency curves for the Ohio main stem were determined in the Ohio River Division office of the Corps of Engineers. Where tributary frequency curves were not known, data from the U.S.G.S. were utilized. These were for observed flows as corrections for flow regulations were not made. Care is required in the use of any frequency information as records are generally too short for more than an estimate. Plates 20a through 20c present curves for nine locations on the main stem Ohio for 30-day average low flow frequencies, natural and modified by Corps reservoirs.

Typical low flow frequency curves, as determined by the U.S. Geological Survey for long periods, are shown on Plate 21 for the Tygart Valley River at Belington, W. Va.; Licking River, Catawba, Ky.; Great Miami River, Taylorsville, Ohio; and Cumberland River, Cumberland Falls, Ky. Curves for the stations show the variations that may occur in the statistical analysis of low flow data from tributaries with different hydrologic characteristics. A brief description of the latter for the four stations follows:

(1) Belington. The Tygart Valley River has its extreme source in the northern part of Pocahontas County, at a 4,000-foot elevation. The topography of the Basin above Belington is precipitous, except for the Tygart Valley, approximately 22 miles long, averaging about a mile wide and lying in that area above Elkins. The stream gradient is steep in the upper reaches, but levels off around Belington. Above here, the Basin is heavily forested and sparcely populated. The minimum average annual runoff for the Monongahela River Basin, in which the Tygart Valley River Basin lies, was 12.9 inches, while the minimum discharge of record, 0.1 cfs, was noted September 13, 1930.

(2) Catawba. The topography of the Licking River above here is hilly to mountainous, with the exception of the area near the head of South Fork, which is rolling. The flood plain of the Basin is comparatively narrow, averaging about one-quarter mile, except in the reach from Mile 150 to Mile 190, where it is approximately a mile. The character of the Basin is predominantly rural. The minimum discharge of record, 2.5 cfs, occurred on August 5 and October 14 and 18, 1930, while the minimum annual runoff is 4.1 inches.

(3) Taylorsville. Glaciation of the Great Miami River Basin has left its topography above here level to gently rolling, and deposited glacial drift aquifers which influence the low flow discharges of the Great Miami River at Taylorsville. The minimum recorded discharge of 30 cfs occurred January 2, 1945. The minimum annual runoff for the Great Miami River Basin is 3.2 inches.

(4) Cumberland Falls. The Cumberland River above the falls to the vicinity of Jellico Creek, a major tributary, flows through a gorge-like section with steep banks. Beyond the creek the river valley widens somewhat to its source, the junction of Poor and Clover Forks, near Harlan. From the Cumberland's source to the falls, its average gradient is about 2.4 feet a mile. The watershed topography is mountainous and densely forested, with a portion of it lying in the Cumberland National Forest. The Cumberland River Basin annual runoff is 8.2 inches, while the minimum discharge of four cfs was recorded September 19, 1954.

The Corps of Engineers determined for key locations in each sub-basin, the seven-day, 10-year low flow discharges, which were used by the U.S. Public Health Service in their water quality studies. These discharges along with the cne-day, 30-year and 50-year low flow discharges are shown in Table 15.

18. Stream Flow Routing. Knowledge of stream flow routings helps one understand the hydraulics of the Basin's natural waterways. The basic hydrologic functions are time of travel and the effect of natural valley storage on the inflow-outflow relations in any given reach. The routing of stream flows is also necessary to determine the effect of reservoirs on flood flows and the release of water for low flow augmentation.

Stream flow routings by the Soil Conservation Service are usually done on a watershed basis in the upstream areas. Routings are made on tributaries, then on the main stem. The same reaches and routing equations are used for the upstream watershed in its "present" condition and for the "future" conditions, with a project assumed completed. When floodwater retarding structures are added to the project, they will reduce volumes of runoff in the original inflow hydrographs, and will create or add hydrographs of the releases from the structures. The routing process remains the same except where a structure site cuts off a reach.

In many of the upstream watershed areas, gaging data from stream flow stations are not available. However, where these are available the records are used to verify the stream hydraulics and the routing parameters. Methods of routing are explained in the Soil Conservation Service National Engineering Handbook. Electronic data processing equipment is used for flood routing through reservoirs and channels with synthetic or natural hydrographs. Project formulations for flood routing and the selections of the most desirable combinations of floodwater retarding structures or channel works of improvement is accomplished by means of a computer program prepared for the Soil Conservation Service by C-E-I-R, Inc., Arlington, Va. This program will flood route through retarding structures and channels with synthetic or natural hydrographs.

a. Flood Flows. Previously established flood routing procedures for the branches and upstream reaches of tributaries were used for this study. For the main stem and the lower reaches of major tributaries the method and routing coefficients for the Standard Project Flood studies are applicable to larger flood flows. Paragraph 35, this appendix, explains the method used for the main stem Ohio Standard Project Flood, and Plate 33 the Ohio River routing reaches and coefficients.

b. Flood Flow Modifications (Holdout Routing). A method of determining the effect of impoundments on flood flows is by reservoir holdout. The difference between a natural hydrograph and one resulting from the reservoir modification is routed downstream. This is to determine the lowering of crest discharge from storage, using the standard methods explained in Corps EM 1110-2-1408. This is generally simpler than routing the modified hydrograph which must be combined with tributary inflow. The routing of floods and reservoir holdouts, programmed on an electronic computer by the Corps Ohio River Division, was used for this study.

c. Low Flow Routing. The routing of low flows is of importance in determining the discharge at downstream points. These data are necessary for stream pollution studies and to determine present and future low flow augmentation needs. For the main stem Ohio, standard stream routing procedures were utilized. The low flow routing coefficients for this report are presented in Table 16.

d. Low Flow Time of Travel. The time of travel in days between locations of interest on the Ohio, for the discharge occurring for a 30-day average low flow with a 10-year chance of occurrence, is in Table 17. Travel times were obtained by dividing the average velocity in a reach corresponding to a 30-day, 10-year discharge into the distance between the pertinent points.

The time of travel in days between some required locations in the tributaries for the seven-day, 10-year low flow discharge was determined by the Public Health Service. The travel time between the remaining required locations in the tributaries was estimated by the Corps of Engineers, by dividing the length of the reach by the average velocity in the reach corresponding to a seven-day, 10-year low flow discharge. The travel time for these reaches is shown in Table 18.

The travel times may be used for steady flow conditions but are not applicable to the movement of waves or surges, which may be caused by releases at dams or by rapid runoff from a thunderstorm. The discharge increase in these cases would cause a greater average velocity, but the sudden introduction of a large volume of water into a flat pool would cause a displacement effect, which would be rapidly transmitted. This velocity is not pertinent to the present study.

19. Stream Regulation. The streams in the Ohio River Basin are regulated by a number of reservoirs purposes of which vary. Each Corps of Engineers impoundment has a flood control function and many have storage allocated for summer or all-season recreation pool, water supply, hydroelectric power, low flow augmentation quality control, navigation, recreation or fish and wildlife conservation. Reservoir levels are often fluctuated for control of insects or rough fish during their breeding seasons. Impoundments operated by states, conservancy districts, public or private power or water supply purposes have similar single or multipurpose functions.

The Soil Conservation Service plans upstream watershed projects which are constructed under Public Law 566 criteria. These reservoirs have flood control functions with additional storage utilized for recreation, fish and wildlife conservation, water supply and quality control and irrigation. The latter three are cost reimbursable by state or local interests. The retarding structures are built with ungated flood control spillways. The plans may also include channel improvement, levees and land treatment and management considerations. Plate 40 is a typical upstream watershed project map.

Throughout the Ohio River Basin, approximately 450 floodwater retarding structures have been planned under Public Law 566. They are in various stages of development, such as constructed, under or authorized for construction, and include some 300,000 acre feet of floodwater storage capacity from approximately 2,500 square miles of drainage area. The Miami Conservancy District detention structures are also of the uncontrolled type.

To determine the effect of the combination of reservoirs on tributary or main stem flow, stream regulation studies and system analyses are required. The Corps reservoirs have been so studied, but impoundments operated by others were not considered, with the exception of the T.V.A. The effects of these other reservoirs on tributary or main stem flow will be discussed in Appendix M, Flood Control. The map on Figure 6 locates the Corps reservoirs, and Table 19 indicates their project purposes and flood and conservation storage in inches.

a. Reservoir Operation Studies. Studies were made to determine the effects of operation of reservoirs for flood control on representative floods. This was determined by applying the approved operation procedures to the storm runoff inflow and routing the reservoir holdouts to pertinent downstream locations.

Each Corps reservoir has a project manual which describes in detail operation of the gates and spillways for various flood and low flow conditions. The manual also includes the design of the dam, procedures for determining the upstream runoff conditions, the stream gages and stages used to determine the reservoir's operating schedule, and the prescribed rule curves.

A typical rule curve for Sutton Reservoir on the Elk River, Kanawha Basin, is on Plate 22. The reservoir operations for 1955 are superimposed on Plate 23. It is operated for flood control throughout the year and for low flow augmentation from June through December. The zone principle is used where the quantity of release is adjusted dependent on the amount of water in storage. A second rule curve for Mansfield Reservoir in the Wabash Basin is on Plate 24. It is operated for flood control with a seasonal pool for recreation. The release of this constant level pool, beginning in early September and completed by December 1, provides incidental low flow augmentation.

Hydrographs for the March-April, 1936, flood at the Sutton Dam and at Frametown on the Elk River are on Plates 25 and 26. The natural and the reservoir-modified discharges are typical of a flood control operation.

b. Average Flood Reduction. A method was developed to obtain average reductions in flood peak discharge for use in estimating the combined effect of all upstream reservoirs on future inundations. The reduction for each representative or hypothetical flood was found by reservoir holdout and routing procedures and plotted against the natural discharge. A curve of best fit was then drawn through these points. It was checked for comparison with those for upstream and downstream locations and adjusted as necessary. A typical one of this type for Pittsburgh is on Plate 27.

c. Modified Discharge. The natural and modified discharge and stage and reductions at key points on the Ohio River for five of the 12 representative floods of record are in Table 20.

d. Modified Flood Frequency Curves. Assuming the Corps reservoirs are in place, modified flood frequency curves were determined for key tributary and main stem stations. Those for the main stem Ohio are on Plates 18a through 18e, together with the natural discharge and stage curves.

e. Low Flow Augmentation. The effect of reservoir releases on low flow discharge for the entire main stem Ohio has not been generalized. Each season is different and the relationship can vary widely of the quantity of water released to that of natural stream flow. The low flow stream discharge measurements with present instruments may be regarded as only an approximation, as there is often disagreement between simultaneous ones made at adjacent upstream and downstream stations. More precise continuous low flow measurements are necessary and additional studies of time and travel and low flow augmentation are required before a system analysis of low flow effects can be made. The effects can be readily determined for individual reservoirs and short reaches downstream. As mentioned previously, reservoirs have various low flow release schedules. Some have no seasonal storage, while others release only at the end of the recreation season and are drawn down by December 1 for the winter flood season. The purpose and various storage allocations and type of release schedule for each reservoir are given in Table 19.

f. Modified Low Flow Frequency. The low flow frequency for the main stem Ohio for the 30-day average discharge for both natural and modified flows was determined for nine stations. Plates 20a through 20c present these frequency curves. The natural flows were determined by routing the actual reservoir modifications produced by the existing projects for each year of study and converting them to pre-reservoir conditions. The discharge frequency was then found by statistical methods. Discharges at particular points were regionalized by developing a curve of drainage areas versus the 30-day, 10-year discharge. For this frequency of flow with reservoir modifications, a relationship between natural and modified flows was determined. The natural 30-day average discharges were plotted against the concurrent modified ones, the points outlining a relatively smooth curve. Given these data it was then possible to draw curves of natural discharge versus modification in flow for the 30-day one with the Group "A" reservoirs. These were then utilized in determining the modified discharge for the various frequencies and a new curve drawn for each site.

Care must be used in comparing the discharge for the same frequency at locations which are some distance apart, as each one's runoff is based on a series of independent events influenced by local runoff and tributary flow. Low flow discharge measurements are neither adequate nor the period of record long enough to make detailed frequency analyses on an entire river system basis.

20. Surface Water Availability Studies.

a. Methodology for Water Availability Studies. The determination of the amount of water available is an essential part of the planning process, and an adequate, good quality supply is needed to stimulate economic development of an area. The planner must know the qualitative and quantitative distribution of the water resources at various locations within the river basin to maximize net returns from potential projects. To determine the quantity of surface water available and that which can be developed, general procedures were used as follows:

The monthly mean flows and the accumulative volume for each station were determined from U.S.G.S. publications. These mass curves were compared with those for various uniform flows for the same period to obtain the storage required for a particular discharge. The requirement in each case is determined by scaling the maximum departure between the mass and the uniform curve. The period during which water would have to be supplied from storage to maintain this flow was also found. The derived data were plotted for curve of flow in cfs per square mile of drainage area versus storage in acre feet for each stream site analyzed. This method is considered satisfactory for general survey and planning purposes involving preliminary studies and estimates of project yields. Plates 28a through 28h can be used for these determinations. Seepage and evaporation losses were not considered in finding the storage required to maintain various flows, as these are relatively minor.

The method although having shortcomings is considered adequate for the scope of this study. For final project and system analysis, more sophisticated statistical methods should be investigated.

b. Use of Ultimate Flow. The ultimate flow approximates the long-term mean discharge. It represents the upper limit of uniform sustained flow that can be theoretically obtained from an area. It is assumed that all flow above the mean can be stored for release when natural runoff falls below it. The ultimate storage is that required to achieve the ultimate flow. Storage in excess of the ultimate will not provide a higher uniform yield unless future wet periods and drought vary considerably from past ones. It is anticipated, however, that future low flow changes will not seriously affect the flow-storage relations.

The optimum flow-storage development for locations within sub-basins was determined, giving the theoretical optimum storage-sustained flow relationship. These storages are large, but no attempt has been made in this phase of the study to determine if they are available at reservoir sites. Those greater than the optimum would give greater flow, but the incremental flow per unit storage would decrease. These figures for various locations are in Table 21. The method used is hypothetical and was developed for the Delaware Basin Report.(1)

These data are useful for long-range planning in order to obtain an idea of the maximum potential development in each basin.

c. Flow Storage Curves. These curves, derived for key locations in each major tributary, are presented on Plates 28a through 28h. They show storage required to maintain a specific discharge in cfs per square mile which may be carried over from one year to another. Although they are for a particular stream gage, they may be utilized for other locations on the same stream within a reasonable distance and drainage area. The point of optimum development is indicated on each curve.

d. Seasonal Volume of Runoff. An indication of the seasonal volume of runoff can be obtained from Table 22 which shows the percent of average monthly runoff as related to the annual figure for six gaging stations. The volume from December 1 to April 1 averages roughly 50 percent of the annual; from April through June it generally approximates 30 percent. Since the major flood season extends through April, some risk is involved that month in storing water for seasonal low flow augmentation or recreation pools. On the other hand, if this runoff is not stored there is great danger of not accumulating sufficient water for seasonal use. The graph on Plate 29 gives an indication of the percent chance of occurrence of various flows in April through May and April through June. Plate 30 is useful in determining the storage required for a specific period of sustained flow, assuming all discharge is from that source. To determine supplemental flow the observed discharge should be subtracted from that desired and the remainder used. The two charts used in conjunction with the water availability curves should be useful in inferring low flow augmentation storage required to satisfy needs.

e. Flow Duration Curves. These curves give an indication of the hydrologic characteristics of a drainage basin. The four on Figure 9 are typical of the glaciated and non-glaciated areas of the Ohio River Basin. The slope on the high flow end is largely governed by climate and physiography, while the low flow end is indicative of the average ground water or other storage released to stream flow. A steep slope in the lower section of the curve indicates low ground water yields, whereas a flat one,

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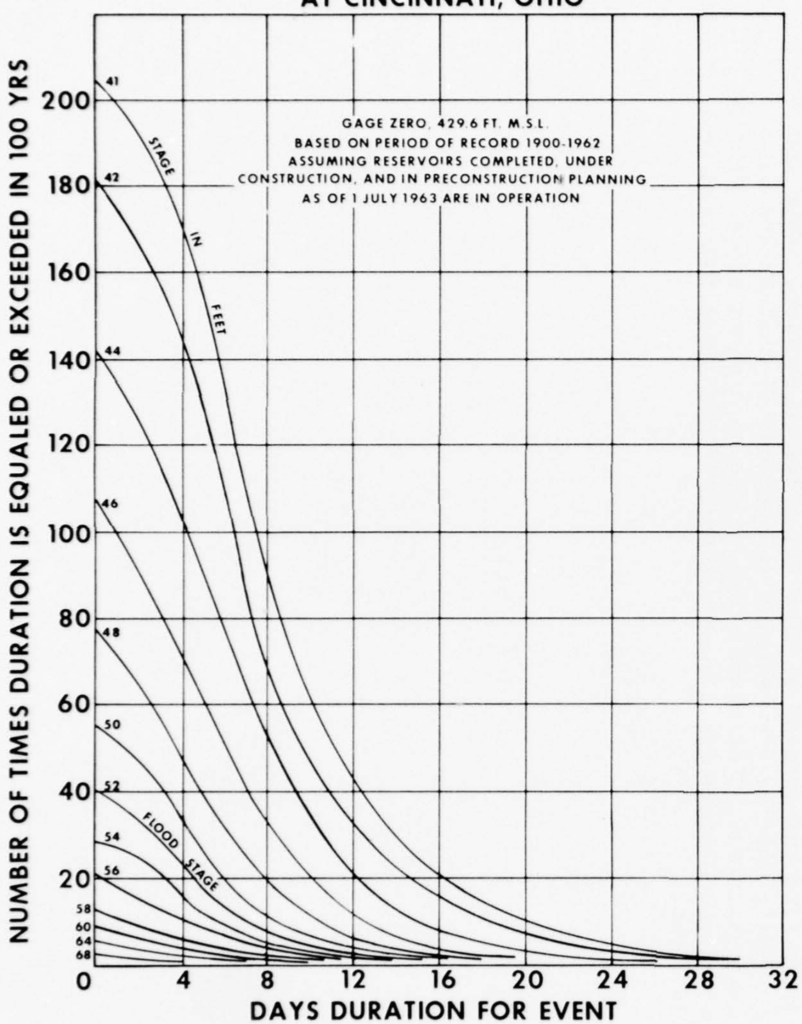
(1) Delaware River Basin Report, U.S. Army Engineer District, Philadelphia, December, 1960, Vol. VI, App. M, Hydrology, p. M-74, para. 128.

shows sustained ground water discharge to the stream or regulation by surface storage. Curves A, B and C are in the Monongahela Basin in the Allegheny Mountains, where infiltration and hence ground water discharge is generally low. Curve A, typical for an unregulated small drainage area, indicates that runoff variation between flood and low flow is great. In this type of basin there are high runoffs during storms and very low flows during droughts, perhaps ceasing entirely at times. Curve B is for an unregulated larger drainage area above Tygart Reservoir. Larger areas tend to increase the low flow discharge per square mile and to have lower flood discharge per square mile. Curve C shows the result of all-year regulation by Tygart Reservoir. Flood-flow peaks are reduced and low flow discharges are raised. The duration of higher low flows is increased.

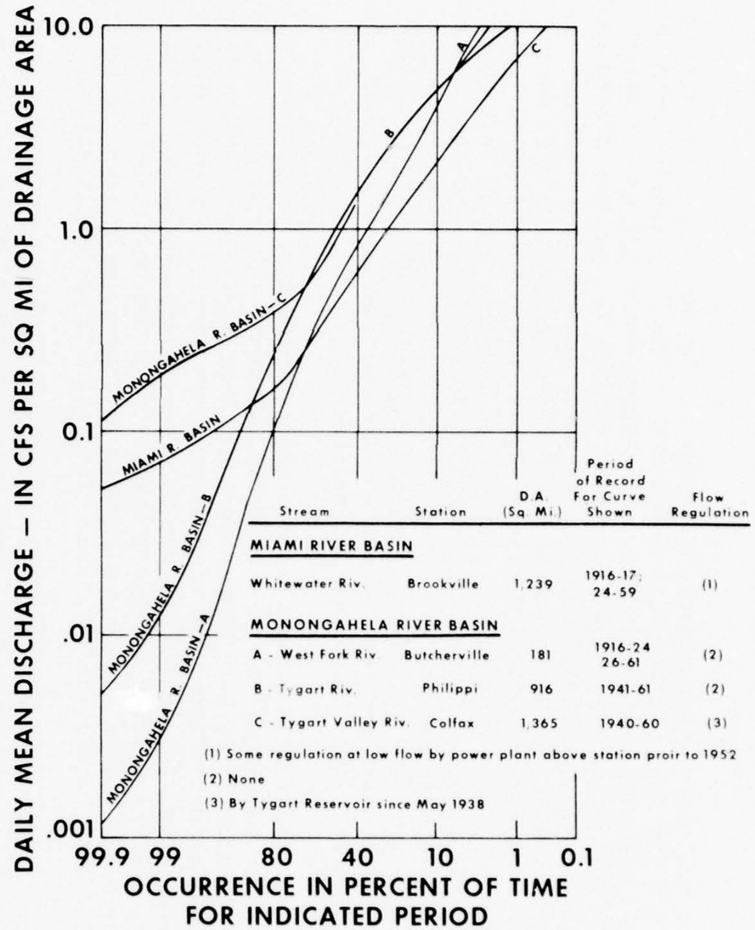
The fourth curve, for the Whitewater River in the Great Miami Basin, shows the effect of a permeable ground water aquifer. The higher infiltration rates and flat topography generally result in lower flood discharges per square mile of drainage area than in the mountainous region. Low flow is greater due to ground water discharge. It may be noted that regulation by Tygart Reservoir in the Monongahela Basin produces a greater low flow discharge per square mile than the natural ground water yields do to stream flow in the Great Miami Basin.

Flow duration curves are useful in hydropower studies to determine the frequency of runoff volume, in local flood protection projects to find the percent of time flows are above flood stage and in water supply and low flow studies the percent discharges are below a designated minimum. The other graph on Figure 9 shows stage duration frequency at Cincinnati for discharges above flood stage for reservoir-modified flows.

STAGE DURATION FREQUENCY
AT CINCINNATI, OHIO



TYPICAL FLOW DURATION CURVES
OHIO RIVER TRIBUTARY STREAMS



Stream	Station	D.A. (Sq. Mi.)	Period of Record For Curve Shown	Flow Regulation
MIAMI RIVER BASIN				
Whitewater Riv.	Brookville	1,239	1916-17; 24-59	(1)
MONONGAHELA RIVER BASIN				
A - West Fork Riv.	Butcherville	181	1916-24 26-61	(2)
B - Tygart Riv.	Philippi	916	1941-61	(2)
C - Tygart Valley Riv.	Colfax	1,365	1940-60	(3)

(1) Some regulation at low flow by power plant above station proir to 1952

(2) None

(3) By Tygart Reservoir since May 1938

FIGURE 9

SECTION V - SEDIMENTATION

21. Available Sediment Data for Ohio River Basin. Suspended sediment records, published by the U.S. Geological Survey, are available for stations located on various streams in the three predominant physiographic provinces. The summary of annual suspended sediment yields and total annual discharges for 26 stations are given in Table 23. Since sediment records for the main stem Ohio have been published intermittently, an estimate of yields is based on partial data.

Sedimentation rates for 42 reservoirs were obtained from publications of the Soil Conservation Service, Corps of Engineers and numerous state agencies. The Corps has set up sedimentation ranges on all reservoirs and these will be measured to obtain long-term effects. Locations of these 26 suspended sediment stations and the 42 reservoir survey sites are shown on Figure 10.

22. Origin of Sediment. In streams of humid climates, sediment origin is predominantly in sheet erosion, with a lesser degree resulting from that of banks. The former is the more or less uniform wearing away of the surface, while the latter is the accelerated destruction of land, including gully and embankment erosion and valley trenching. The quantity and particle size characteristics of sediment in a watershed depend principally upon:

a. Rock and soil types.

b. Land use, and amount and management of forest and other vegetation in the watershed.

c. Intensity, amount and form of precipitation.

d. Slope of the ground surface.

23. Sediment Factors. The factors relating to the amount of sediment transported by streams are velocity, discharge and turbulence. The sediment may vary in size from cobbles to silts and clays, and is composed of suspended and bed loads. The suspended one refers to the sediment in suspension, held there by turbulent currents or colloidal suspension. Bed load refers to those particles which are rolled or tumbled along the stream bottom.

24. Sediment Yields. Sedimentation yields in the three physiographic provinces of the Ohio River Basin vary widely. In order to evaluate relative rates of erosion, the sediment yields at various locations in a basin were compared. The yield was obtained by dividing the suspended sediment discharge for a specific time period by the drainage area at the location.

LOCATION OF SUSPENDED SEDIMENT STATIONS AND RESERVOIR SEDIMENTATION SURVEY SITES IN THE OHIO RIVER BASIN AS LISTED IN TABLES 23 AND 24

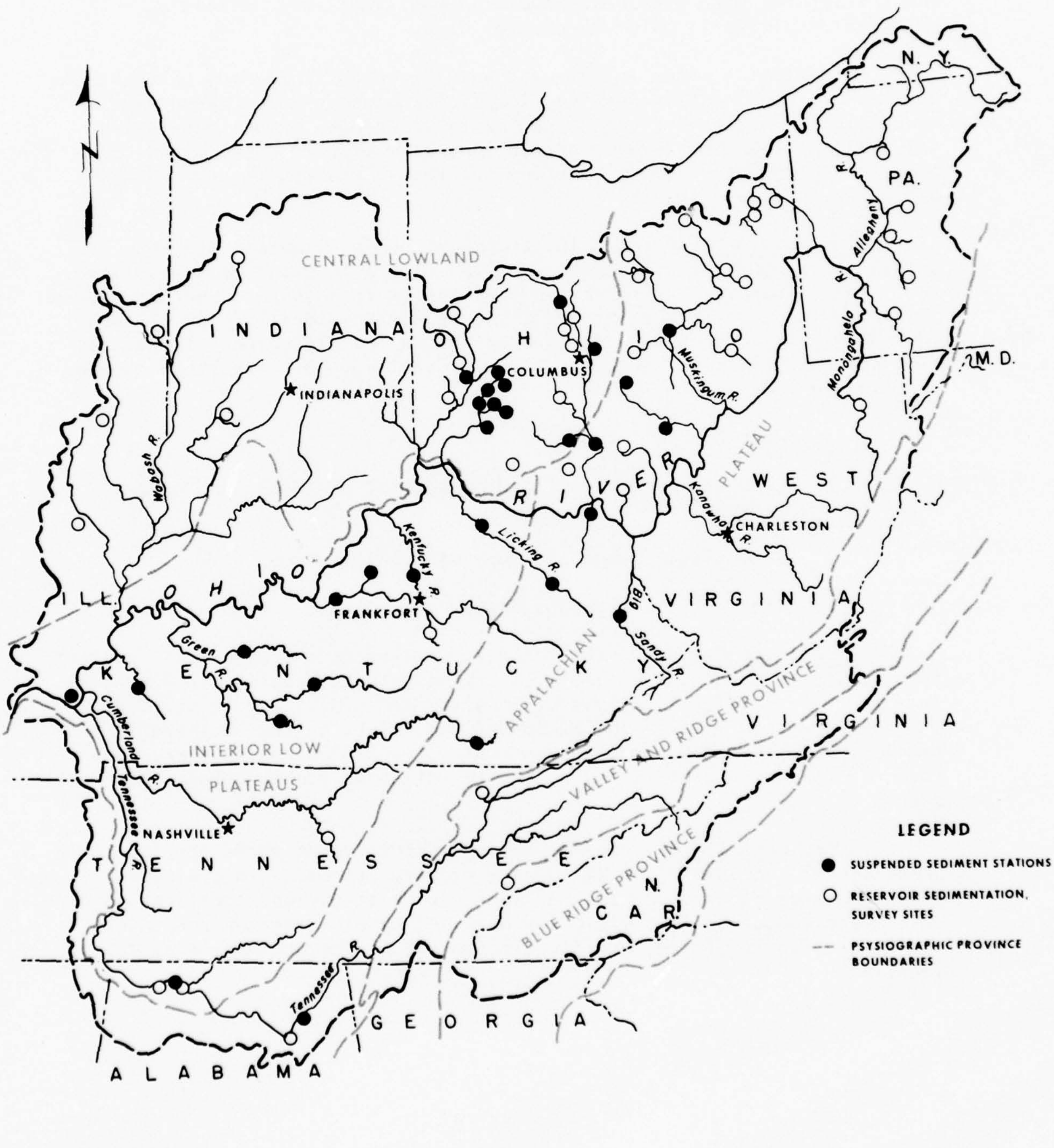


FIGURE 10

An examination of the 26 suspended sediment stations as presented in Table 23, reveals that the Salt River Basin in the Interior Low Plateaus province, had some of the highest yield rates. For water year 1960, Plum Creek, Waterford, Ky., a tributary of the Salt, had a suspended sediment yield of 2,410 tons per square mile of drainage area. Assuming the unit weight of sediment at 60 pounds per cubic foot, this amounts in volume to 1.85 acre feet for the water year. Some factors which may aggravate the sediment problems in this province are:

a. Strip mining operations which destroy vegetation and forest cover and create unprotected spoil banks that are easily eroded. Many operations undertake to reclaim the land by grading and revegetation.

b. The portion of Kentucky lying in this area is the most intensively farmed, leaving much land surface exposed during the growing season, when intense rains are common.

c. The remainder of the area has relatively steep land slopes.

Since there is a lack of sediment data for that portion of the Appalachian Plateau province lying south of the Ohio River, caution should be used when applying to this section the sedimentation rates derived in this report.

Low sediment yields were found in the Central Lowland province. Although this area is cultivated extensively, erosion is relatively less because of the flat and gently sloping land. Low yield for specific locations are found in the Muskingum, Tradewater and certain areas of the Little Miami River sub-basins. For water year 1954, the Little Miami River near Selma had a suspended sediment yield of 6.8 tons per square mile or .00523 acre foot per square mile. Land management practice which holds the soil is one explanation for low yields in the Tradewater and certain areas of the Little Miami River sub-basins. Headwater reservoirs in the Muskingum River sub-basin, which retain the upstream sediments, result in the low suspended yield rates at Dresden.

25. Reservoir Sedimentation. The reduction of storage capacity by sedimentation, commonly referred to as reservoir silting, represents the loss of a natural resource. In some cases, reservoir sediment may include organic material (limbs, leaves, etc.). This material will decompose after a period of time, but initially require reservoir storage space. Factors which have an effect on the rate of silting are:

a. Amount, type and distribution of sediment carried into reservoir.

b. Reservoir shape.

c. The reservoir capacity - watershed area ratio.

d. Detention time of reservoir inflow.

e. Fluctuations in water levels of the reservoir.

f. Physical and chemical differences in the inflow and reservoir content.

Reservoir silting in the Ohio River Basin is not a major problem as compared to some western areas, such as the Colorado River Basin. In previous Corps reservoir studies in the Ohio Basin, an annual sedimentation rate of 0.2 to 0.5 acre foot per square mile of drainage area has been used for design purposes. The Soil Conservation Service reports that annual sedimentation rates for the Basin Public Law 566 watershed project designs have ranged from 0.05 to 2.5 acre feet per square mile of drainage area.

This law, also known as the Watershed Protection and Flood Prevention Act, has specific requirements pertaining to drainage area treatment. In addition to providing storage capacity, the economic life of floodwater retarding structures is insured against sediment encroachment through proper watershed land use, treatment and management.

The measured rates from sedimentation surveys for reservoirs in the physiographic provinces in the Ohio River Basin are shown in Table 24. They range from 0.02 to 1.30 acre feet per square mile. These vary as the result of detention directly upstream to earthwork activities immediately prior to sampling or length of record. The silt contributing drainage areas above these reservoirs ranged from 11.7 to 5,033 square miles, while the period of survey was 3.3 to 107 years.

Generalized curves, as shown on Plate 31 were developed for the three physiographic provinces from sedimentation and suspended sediment dates for reservoirs and stations in and adjacent to the Basin. These curves represent average values and if applied to specific sites, appreciable variations might result. For final project design, detailed studies should be made.

The Soil Conservation Service finds that isolated high-sediment producing areas could have significant effect on upstream watershed developments. Reservoir sedimentation design rates vary several fold from one structure site to another within a watershed project of less than 100 square miles. S.C.S. Engineering Technical Release No. 12 presents methods and procedures for computing sediment storage requirements for retarding and multiple-purpose structures.

<u>26. Deposition in Channels</u>. Although reservoir silting is a major aspect of sedimentation, other resulting problems are:

a. Sediment deposits in navigation channels and harbors, requiring periodic dredging.

b. Increased frequency of flooding as a result of deposition in channels.

c. Destructive silting of agricultural land.

d. Damage during floods to structures and contents, and to mechanical equipment through silt diffusion.

e. Change in ecology and fish and shellfish harvest.

f. Impedes drainage on adjacent farmlands.

SECTION VI - OHIO RIVER STANDARD PROJECT FLOOD

27. Purpose. The term Standard Project Flood (SPF) is defined as a hypothetical flood, representing the critical volume and peak discharge that may be expected from a combination of meteorologic and hydrologic conditions reasonably characteristic of the geographical region. It represents a standard against which the degree of flood protection selected, called the Project Design Flood (PDF), may be judged and compared with protection provided by similar projects in other localities. The primary objective of this phase of the study was to establish SPF hydrographs at key locations along the Ohio River.

28. Scope. Following the flood of January-February, 1937, studies of a comprehensive flood control plan for the Ohio River Basin were made. These included the determination of a Standard Project Flood for the main stem Ohio. The system of reservoirs recommended on the basis of the 1937 study, essentially that authorized by the 1938 Flood Control Act and prior acts, would reduce the project flood to stages close to the maximum of record along the Ohio from Wellsville, Ohio, to the mouth. The PDF profile then selected for construction of local protection works was established as the modified SPF between Pittsburgh and Wellsville, and the maximum flood of record between Wellsville and Cairo. Local protection works constructed since 1937 provide three feet of freeboard above the grade of the PDF. Subsequent to establishment of the 1937 PDF changes have occurred that make impractical construction of some of the presently authorized reservoirs. Because of these and in light of accumulated experience, the latest developments in meteorologic and hydrologic techniques and currently available data, a reappraisal of the SPF was included in the present comprehensive study.

This reappraisal considered the meteorologic and hydrologic situations, the related rainfall and runoff quantities in the Ohio Basin and the resulting discharges at key points along the Ohio, between Pittsburgh and Cairo. Selected storm patterns and combinations were used to develop hypothetical floods. Since it is unlikely that any one storm or single combination of them will produce critical flows throughout the entire length of the River, more than one hypothetical flood was considered necessary to represent SPF criteria. Comparable probabilities of occurrence of the developed standard project floods were examined to determine the consistency of discharges and to serve as a basis for the selection of design criteria at key locations. Standard project floods for tributaries were not determined as part of this study.

29. Previous Flood Studies. Previous flood studies are summarized in paragraphs a and b following:

a. Flood of March-April, 1913. The report on the Ohio River, published August 23, 1935, as House Document No. 306, 74th Congress, 1st Session, contained a study based on the flood of March-April, 1913, the maximum of record at that time for which adequate data were available.

It was assumed that a storm similar to that of March 1913, could occur, centered over the axis of the Ohio Basin instead of the actual position, which was approximately 130 miles north. On the basis of the ratio of depths of rainfall of the assumed storm condition to actual ones applied to the maximum rates of discharge during the 1913 flood, the figures at stations on the main stem Ohio were developed. In the planning of local protection projects it was proposed that the design grade be such as to provide a freeboard of five feet for levees and three for concrete walls above the maximum flood of record. Table 25 contains maximum stage and discharge data for the March flood and the estimated project one, as presented in House Document No. 306, and the maximum stages of record at the time of the report for comparison purposes.

b. Flood of January-February, 1937.

(1) Following this, the flood situation in the Basin was restudied and a project flood was developed and design grades set up for local protection structures on the Ohio. The results are contained in an unpublished report dated November 12, 1937, subject, Comprehensive Flood Control Plan for the Ohio River Basin.

(2) The 1937 Project Flood was developed on the basis that, although the continuous rainfall experienced January 6-25 was the greatest flood-producing precipitation on record, changes in meteorological conditions during the storm period could have added two to four inches in the upper Basin and in the tributary ones north of the Ohio. The following procedure was used in determining the rainfall producing the project flood:

(a) The 1913 storm center over the Great Miami River was transposed over the watershed of the Allegheny and Monongahela Rivers. The rain which fell March 23-27 was assumed to replace that of January 16-20, 1937, so that its runoff would coincide with the crest in the lower Ohio.

(b) The rain March 23-27, 1913, in the Wabash, Great Miami, Scioto, Muskingum and Beaver watersheds was assumed to replace that of January 21-25, 1937, so that their runoff would also generally coincide with the crest in the lower Ohio.

(c) Rainfall on other portions of the Basin was assumed to have been identical with that of January 6-25, 1937.

(3) The method outlined of developing the project flood enabled utilization of actual in lieu of hypothetical runoffs, based on assumed rainfall-runoff relationships.

(4) Table 26 lists the maximum stages and discharges produced at points on the Ohio River by the project flood and also the maximum stages and discharges of record as listed in the report of November 12, 1937.

(5) Reservoir operation studies made in connection with the November 12, 1937, report indicated that a system of 68 reservoirs (39 proposed for Ohio River flood control in addition to 14 authorized by the Flood Control Act of June 22, 1936, and 15 constructed under prior authority) would reduce the project flood stages substantially below maximum ones of record in the 50-mile reach between Pittsburgh and Wellsville, Ohio. Between Wellsville and Cairo, the project flood would be reduced to stages equivalent to the past maximums. The basis proposed for design of local protection projects was three feet freeboard above the profile of the modified project flood from Pittsburgh to Wellsville and the same above the maximum flood of record profile from Wellsville to Cairo. Table 27 shows the stages of the maximum flood of record and natural and modified project flood stages at locations along the Ohio River as determined in the study.

30. Current Study - Basic Procedure. Records of past storms and floods indicate that more critical combinations of rainfall and runoff in the Ohio River Basin may be reasonably anticipated. Studies have shown that a slight shift in storm position or in the sequence of events would have resulted in greater flood discharges than those actually experienced. Accordingly, hypothetical combinations of storms of record were developed to determine flood flows that have a reasonable chance of occurrence. The hypothetical combinations include a flood period preceding a storm or flood flows that could reasonably be expected to precede the initial storm, and two major storms of record, with timing between them consistent with meteorological conditions for those used, or for similar ones. The hypothetical sequences were developed on the basis of both major storms in place; one in place and one transposed from its original position, or both transposed. Adjustments in timing of the storm occurrences and in rainfall were made as necessary to conform to appropriate meteorological conditions. Because of runoff characteristics of the drainage basin, it was considered that two storms in combination, with appropriate antecedent conditions, would develop the most critical flood conditions. Since it is unlikely that one storm would develop critical conditions over the entire length of the Ohio River, the selection and positioning of the major ones was carried out with a view to developing floods specific to the upper, middle and lower river sections. Where possible, actual recorded flows resulting from storm rainfall were used in determining flood flows. For transposed storms, or where reliable records of actual flows were not available, the flood runoff was found by application of unit hydrographs to observed rainfall quantities.

31. Unit Hydrographs. For preliminary study of hypothetical floods, runoff quantities were developed using 24-hour tributary unit hydrographs and rainfall quantities. These unit hydrographs were determined by routing unit hydrographs for subdrainage areas in the tributary basin to the station nearest the mouth of the tributary. The routed units were combined at that point to form the composite hydrograph. For detailed study of the more critical floods, including reservoir operation studies, six- and 12-hour unit hydrographs were used. These were developed from

analysis of floods of past record in accordance with the method described in EM 1110-2-1405. Six-hour unit hydrographs were picked for areas upstream of Lock and Dam 33, Maysville, and 12-hour ones for areas from Lock and Dam 33 to 52, Metropolis. There were 304 unit hydrographs used, with an average drainage area of 667 square miles, in developing flows for the hypothetical floods selected for detailed study.

32. Infiltration Indices. Curves for rainfall-excess plotted against precipitation for six-hour periods, contained in Appendix C, Interim Report on Storms and Floods in the Kansas City District, May-June, 1951, were considered suitable for use in the project flood study. These curves, shown on Plate 32, take into account the probable variation in rainfall over a six-hour period.

33. Recession Curves and Base Flows. Normal recession curves were developed for the Standard Project Flood from observed flood hydrographs at Ohio River and tributary gaging stations. These were used for the hypothetical flood hydrographs to adjust recorded flows for periods of no rainfall in the storm sequences used. In the development of hydrographs from rainfall, base flows were determined from study of those for natural discharge for various seasons. These adopted for Ohio River stations are also listed on Plate 32.

34. Rainfall Excess. For preliminary flood studies a base map was prepared for transposed storms and those in place for which runoff was to be computed from rainfall. Average 24-hour rainfall amounts were developed for each unit hydrograph area by the Thiessen Method. These were corrected, as required, by application of adjustment factors for geographical relocation, seasonal change and orographic depletion as determined by the Weather Bureau. By use of infiltration indices and curves of rainfall excess plotted against 24-hour precipitation, the net effective precipitation for each 24-hour period was determined for the unit hydrograph area. The same procedure decided net effective rainfall for the storm sequences selected for detailed study, except that quantities were determined for six-hour periods for each of the 304 unit hydrograph areas. Where six-hour isohyetal maps were available, they were utilized to determine average rainfall amounts on the unit hydrograph areas.

35. Flood Routing. Routing of natural flood flows and reservoir modifications was accomplished by the Muskingum Method, using two constant coefficients. The variable coefficients are approximately constant in the range of flood flows and were not employed. The use of constant coefficients enabled the work to be accomplished more readily by an electronic digital computer. For the hypothetical flood, 11 Ohio reaches were employed, with a routing period of 12 hours, except in the first two from Pittsburgh to Wheeling, where the time period was six hours. The routing reaches and coefficient values used are on Plate 33.

36. Storm Combinations. Available data on 28 past record storms, adjacent to or over the Ohio River Basin, were analyzed to determine the

areal extent, rainfall intensity and duration, suitability of meteorological conditions for transposition within or into the Ohio Basin and combination with others, and flood-producing potential. A comparison of rainfall data pertaining to these storms is shown in Table 28. Forty-one different storm combinations were examined, of which 16 were selected for detailed study. These storm combinations were designated by numbers running from OR-1 to OR-90, according to seasonal occurrence. In selecting the combinations, consideration was given to potential for producing critical natural flood flows and possible effectiveness of reservoirs in reducing peak flows. The storm combinations with the periods of rainfall, storm transpositions and time and meteorological adjustments are shown on Plates 34a and 34b.

37. Meteorological Studies by Weather Bureau. A meteorological analysis of 15 of the proposed 16 hypothetical storm sequences has been completed by the Weather Bureau. Data for them are contained in the bureau's publication, Meteorology of Flood Producing Storms in the Ohio River Basin, Hydrometeorological Report No. 38.

38. Hypothetical Floods - Preliminary Study. Tributary runoff hydrographs were computed for each of the hypothetical storm sequences except OR-68. These were routed down the Ohio River and combined with computed local inflow to develop the hypothetical flood hydrographs at key stations on the main stream. Where reliable discharge records were available, the record floods resulting from storms as they occurred were adjusted by means of recession curves, to include only the runoff from rainfall of specified periods. Where discharge records were not available for record inundations from storms in natural position and for floods resulting from transposed ones, flows were determined by applying rainfall excess for 24-hour periods to tributary unit hydrographs. Flood hydrographs for OR-68 were not developed as only one storm, July-August, 1875, transposed to a position north of the Ohio River, is involved. It was considered unlikely that Ohio River flows resulting from the transposed storm would be critical. OR-5A and OR-1 are made up of the same combinations except that depletion factors have been applied to the 1937 rainfall values in the former. Table 29 lists comparative data on peak flows at Ohio River stations for the 15 hypothetical floods.

39. Hypothetical Floods - Detailed Study. On the basis of the hydrographs made in the preliminary planning, four hypothetical floods were selected for detailed study. Storm combinations and arrangements of these are:

a. OR-1 consists of the storm of January 5-24, 1937, with the storm transposed approximately 240 miles east-northeast and followed after four intervening days of no rain by the actual storm of January 3-16, 1950. No adjustments were made in rainfall quantities.

b. OR-5A consists of the same storm combination as OR-1. Barrier depletion factors were applied to the 1937 transposed rainfall varying from 16 percent in the headwater areas of the eastern tributaries to one percent in the lower Basin.

c. OR-21 consists of the March 23-26, 1913, storm transposed approximately 158 miles east and 43 miles south and rainfall quantities increased two percent. A barrier depletion adjustment varying from seven to 18 percent was applied to the southeastern storm's portion. The March 24-26, 1904, storm followed after three intervening days. This was transposed approximately 200 miles east-northeast and the rainfall decreased by six percent.

d. OR-24 consists of the March 23-26, 1913, storm as it occurred with no adjustment in rainfall, followed after three intervening days by that of March 24-27, 1913. The second storm was transposed approximately 115 miles southeast and the pattern rotated seven degrees counter-clockwise. Rainfall quantities were increased by five percent. A barrier depletion adjustment varying from seven to 18 percent was applied to the southeastern portion of the transposed storm.

MRC-58A was a hypothetical flood developed and adopted by the Mississippi River Commission as a project flood for the mouth of the Ohio River. This consists of the January 5-24, 1937, flood in place, increased by 10 percent (in lieu of transposing to a more critical position), followed in four days by the observed January 3-16, 1950, inundation.

Hydrographs for these hypothetical floods were completed by the same procedure as in the preliminary studies, except that rainfall quantities were determined for six-hour periods. They then were applied to small area unit hydrographs. Isohyetal maps, mass rainfall curves, and area-depth-duration curves for OR-1, OR-5A, OR-21 and OR-24 are shown on Plates 35 through 37.

40. Ohio River Basin Flood Control Reservoirs. The basin plan for flood control and allied purposes in the Ohio River, authorized by the 1938 Flood Control Act and previous ones, consisted of 79 reservoirs and 235 local flood protection projects. Subsequent legislation has authorized additional reservoir projects and deauthorized others. As of Fiscal Year 1964, the basin plan includes 88 authorized reservoirs (38 having been constructed), nine under construction and advanced engineering studies being made on six. In the Tennessee River Basin, 18 T.V.A. reservoirs have been constructed to provide storage for modification of flood flows. Table 30 lists data used for SPF determination on the authorized reservoirs in the Ohio River Basin.

41. Reservoir Operation Studies for the Standard Project Flood. For these studies the dependable effects of reservoirs in reducing stages of the hypothetical floods were considered to be those reductions afforded by existing reservoirs and those expected to be completed in the near future. Accordingly, the effects of reservoirs in reducing flows of hypothetical floods OR-1, OR-5A, OR-21, OR-24 and MRC-58A have been

computed. Operations during the flood periods were in accordance with approved reservoir regulation schedules, which provide for releases according to conditions at control stations on the Ohio River and the tributary streams. Modifications effected by the reservoirs were routed downstream and combined with natural flows at stations on the Ohio to determine the modified hydrographs. Natural and modified peak stages for these floods are listed in Table 31.

42. Standard Project Flood Profile. The Ohio Basin Standard Project Flood profile is shown on Plate 39. Figure A shows the SPF peak elevations for the Ohio River for natural flows and as modified by Corps reservoirs completed, under construction and in advanced planning as of July 1, 1963. Figure B depicts natural and modified stream discharges. Figure 8 demonstrates the effects of Corps reservoir systems at selected key locations, with the shaded area in the bar representing that reduction, due to the tributary system indicated at the first location downstream from the junction with the Ohio River.

In selecting the hypothetical flood for key locations on the Ohio, consideration was given to record inundations, reasonableness of storm combinations and the relative consistency of station-to-station peak flows. To test the station-to-station consistency, peak discharges were compared with frequency data derived by Beard's Method from individual station records shown in Table 32. Although the frequencies are not comparable, the variation of flow per square mile of drainage area for the SPF is consistent with the variation found in derived data for shorter recurrence intervals.

The SPF is not supposed to represent the maximum possible flood, but is expected to correspond to a flood of rare occurrences, such as might result from storm sequences reasonably characteristic of the area. It cannot be expected that any one combination of storm rainfall events will produce critical flood peaks at all locations along the Ohio River, because of the size of the basin and the nature of runoff characteristics.

The establishment of the SPF does not restrict the freedom of the engineer and planner to select some lower or higher discharge for the final project design flood, if circumstances warrant. On the contrary, an unusually "stable tool" is provided to aid in the selection of safe design criteria, and a "standard of comparison" is provided to aid in judging comparability of design flood selection for various key locations.

Plates 38a through 38c are hydrographs for the SPF at key Ohio River locations. Flood OR-21 is selected as the SPF for the reach from Pittsburgh to Huntington, OR-5A for Maysville to Golconda, and MRC-58A for the reach below Golconda to the mouth.

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TABLE 1

PERTINENT DATA - PRINCIPAL TRIBUTARIES OF THE OHIO RIVER

Tributary	Miles above Mouth of Ohio River	Miles below Pittsburgh, Pa	Length of Main Stream - Miles	Drainage Area - Square Miles
Allegheny	981.0	0	325	11,700
Monongahela	981.0	0	128	7,400
Beaver	955.6	25.4	21	3,130
Muskingum	808.8	172.2	112	8,040
Little Kanawha	796.4	184.6	160	2,320
Hocking	781.7	199.3	100	1,190
Kanawha	715.3	265.7	97	12,200
Guyandotte	675.8	305.2	166	1,670
Big Sandy	663.9	317.1	27	4,280
Scioto	624.5	356.5	237	6,510
Little Miami	516.9	464.1	90	1,760
Licking	510.8	470.2	320	3,670
Great Miami	489.9	491.1	161	5,400
Kentucky	435.2	545.8	255	6,970
Salt	351.1	629.9	125	2,890
Green	196.8	784.2	370	9,230
Wabash	133.0	848.0	475	33,100
Saline	113.7	867.3	27	1,170
Tradewater	107.6	873.4	110	1,000
Cumberland	60.6	920.4	693	17,920
Tennessee	46.5	934.5	652	40,910
Mouth of Ohio	0	981.0	981	203,940

TABLE 2

TYPICAL SLOPES OF REPRESENTATIVE STREAM REACHES

	Slope-Feet Per Mile		
River	Average	Headwater	Near Mouth
Allegheny	2.7	33.2	0.9
Monongahela	1.15	1.6	0.6
Youghiogheny	17.9	29.1	1.1
Tygart Valley	19.6	32.6	9.2
West Fork	7.5	20.0	0.96
Beaver	4.1	1.6	11.3
Muskingum	1.5	2.1	1.4
Little Kanawha	9.0	90.0	1.2
Hocking	4.5	17.7	2.1
Kanawha	1.4	15.0	0.4
New	8.0	13.4	3.7
Gauley	21.7	29.4	3.4
Guyandotte	6.3	11.0	1.8
Twelvepole Cr	9.2	45.0	2.5
Big Sandy	1.2	4.6	0.66
Levisa Fork	11.3	12.1	1.0
Tug Fork	10.9	19.9	0.83
Little Sandy	8.7	41.4	2.1
Scioto	2.4	7.3	2.1
Little Miami	7.3	14.1	4.7
Licking	1.7	2.3	1.1
Great Miami	3.6	2.9	5.8
Kentucky (Main Stem)	0.8	1.3	0.65
Salt	6.1	23.3	0.9
Green	2.0	4.1	0.22
Barren	4.6	10.5	0.27
Rough	2.8	8.6	0.40
Wabash	1.5	4.1	0.6
Salamonie	4.9	9.6	0.6
Mississinewa	6.6	11.3	1.1
White	3.0	5.5	0.6
Cumberland	1.3	2.4	0.6
Ohio	0.4	0.9	0.3

TABLE 3

FREQUENCY OF SUSPENSION OF NAVIGATION DUE TO ICE
Ohio River

	Parkersburg 30 Years	Louisville 30 Years
1 Day or More	2 in 5 Years	-
6 Days or More	1 in 4 Years	1 in 6 Years
11 Days or More	1 in 5 Years	1 in 10 Years
16 Days or More	1 in 7 Years	1 in 14 Years
21 Days or More	1 in 8 Years	1 in 16 Years
26 Days or More	1 in 11 Years	1 in 20 Years
31 Days or More	1 in 25 Years	-

TABLE 4

CLIMATOLOGICAL DATA FOR SELECTED OHIO RIVER BASIN STATIONS

Station	County	Sub-Basin	TEMPERATURE Period of Record	Average Annual Avg	Average Annual Jan	Average Annual Jul	Extremes of Record Max	Date	Min	Date	PRECIPITATION Period of Record	Avg Annual	Max Month	Min Month	Extremes of Record Max Year	Date	Min Year	Date	SNOWFALL Inches Average Annual	FROST Average Killing Frost Last	First
Jamestown, N Y	Chautauqua	Allegheny	26-55	48.9	27.3	71.2	100	(7-36)	-25	(2-34)	26-55	42.98	11.00	0.63	54.38	1937	30.18	1941	94.4	5-15	10-6
Pittsburgh, Pa	Allegheny	Allegheny	71-61	52.6	30.9	74.4	103	(8-18)	-20	(2-99)	71-61	36.26	10.25	0.06	50.61	1890	22.65	1930	29.9	4-20	10-23
Warren, Ohio	Trumbull	Beaver	92-62	50.7	29.4	72.8					92-62	36.54			47.07	1911	26.14	1960	50.3	5-12	10-07
Akron, Ohio (1)	Summit	Cuyahoga	21-50	49.7	27.4	72.4	104	(7-18)	-20	(2-99)	21-50	37.26	11.98	0.22					36.1	4-29	10-20
Columbus, Ohio	Franklin	Scioto	78-63	52.7	30.9	74.8	106	(7-36)	-20	(2-99)	78-63	36.67	10.71	0.10	51.30	1882	21.60	1930	21.9	4-17	10-30
Cincinnati, Ohio	Hamilton	Ohio	15-61	54.6	32.3	76.4	109	(7-34)	-17	(1-36)	15-61	39.57	13.68	0.17	53.94	1957	22.76	1934	17.3	4-15	10-25
Elkins, W Va	Randolph	Monongahela	00-63	50.6*	32.2	70.1	99	(8-18)	-28	(12-17)	00-63	45.98*	11.10	0.26	65.37	1907	29.38	1930	47.2	5-4	10-12
Parkersburg, W Va	Wood	L Kanawha	85-63	54.5*	33.5	75.4	106	(-18)	-27	(-94)	85-63	39.15*	12.05	0.07	62.67	1890	19.70	1930	24.1	4-18	10-19
Charleston, W Va	Kanawha	Kanawha	01-63	56.8*	37.4	76.4	108	(7-31)	-17	(12-17)	01-63	44.43*	13.54		60.64	1950	26.13	1930	16.8	4-20	10-23
Bluefield, W Va	Mercer	Kanawha	31-60	54.1	37.1	72.2	99	(7-)	-25	(12-)	31-60	41.56	10.87	0.09	60.03	1901	27.00	1930		4-28	10-11
Williamson, W Va	Mingo	Big Sandy	01-63	57.3*	37.8	77.6	105	(7-)	-13	(12-)	01-63	43.73*	11.87	0.10	68.12	1929	31.67	1930		4-13	10-26
Huntington, W Va	Cabell	Ohio	21-50	57.4	38.0	74.1	108	(7-30)	-24	(2-99)	21-50	41.79	8.93	0.22					15.5	4-17	10-20
Williamsburg, Ky	Whittley	Cumberland	31-60	58.0	39.7	77.2	108	(8-)	-19	(2-)	31-60	46.74	13.33		62.16	1890	36.00	1947		4-19	10-21
Lexington, Ky	Fayette	Kentucky	21-50	54.4	32.5	75.7	108	(7-36)	-20	(2-99)	21-50	43.71	16.65	0.11					19.1	4-13	10-28
Louisville, Ky	Jefferson	Ohio	05-61	56.5	34.9	77.9	107	(7-36)*	-20	(1-84)	21-50	41.47	19.17	0.07	59.39	1950	23.88	1930	13.4	4-01	11-07
Paducah, Ky	McCracken	Ohio	93-63	58.4	36.5	79.9	112	(7-)	-17	(1-)	82-63	46.05*	19.22		72.35	1927	26.32	1963		4-04	10-30
Nashville, Tenn	Davidson	Cumberland	71-63	59.6	39.2	79.5	107	(7-52)	-13	(2-51)*	71-63	46.28	14.75	0.03	67.24	1880	32.74	1871	8.2	3-23	11-07
Evansville, Ind	Vandeburgh	Ohio	21-50	57.0	34.4	79.0	108	(7-36)	-23	(2-51)	21-50	41.37	14.78	0.01	63.13	1950	25.60	1930	10.1	4-02	11-04
Indianapolis, Ind	Marion	Wabash	21-50	52.5	28.8	76.0	107	(7-34)	-25	(1-84)	21-50	39.69	12.69	0.21	57.65	1876	27.93	1954		4-17	10-27
Bluffton, Ind	Wells	Wabash	33-62	51.4	27.5	79.5	111	(7-36)*	-20	(1-36)	33-63	36.76	10.39	0.28	51.42	1959	26.63	1934	24.8	5-05	10-09
			95-63				111	(7-14-36)*	-23	(1-3-04)											
Ft. Wayne, Ind (1)	Allen	Maumee	21-50	49.9	26.3	73.6	106	(7-36)	-24	(1-18)	21-55	36.21	10.9	0.20					29.4	4-24	10-20
Urbana, Ill	Champaign	Wabash	89-62	51.8	26.9	75.3	109	(7-)	-25	(2-)	89-62	35.85	11.58	T	48.47	1898	23.87	1894	21.1	4-23	10-21

* 1931-1960 30 Year Normals.
(1) Station is located outside of Ohio River Basin.

TABLE 5

AVERAGE RELATIVE HUMIDITY FOR SELECTED OHIO RIVER BASIN STATIONS

Location	Nashville, Tenn (Berry Field)		Elkins, W Va		Columbus, Ohio (Port Columbus Airport)		Pittsburgh, Pa (Greater Pittsburgh Airport)	
Time of Observation	6:00 AM	12:00 Noon	7:30 AM	1:30 PM	7:00 AM	1:00 PM	7:00 AM	1:00 PM
Years of Record	70	40	15	15	18	18	8	8
January	84	67	85	67	82	71	78	67
February	80	62	85	66	81	66	76	65
March	78	56	84	58	77	58	77	58
April	76	51	82	53	79	55	75	52
May	79	53	87	53	79	55	75	52
June	79	52	91	59	81	55	79	54
July	81	53	93	59	83	52	83	54
August	84	54	96	54	86	52	86	56
September	85	52	96	52	86	50	85	53
October	84	51	93	49	86	53	83	55
November	81	58	85	56	82	62	88	58
December	82	65	84	63	82	69	87	66

TABLE 6

OHIO RIVER BASIN CLIMATOLOGICAL STATIONS

Sub-Basin	Precipitation Only				Precip & Temp (1)			Temp & Evap (1)			
	Recording	Non-Recording	Both	Total	Non-Recording	Both	Total	Non-Recording	Both	Total	Total
Allegheny	15	34	11	60	15	13	28	0	1	1	89
Monongahela	8	25	2	35	18	2	20	0	2	2	57
Beaver	6	3	1	10	13	2	15	1	0	1	26
Muskingum	5	19	4	28	15	6	21	2	2	4	53
Little Kanawha	2	1	0	3	5	0	5	0	0	0	8
Hocking	5	13	0	18	2	0	2	0	0	0	20
Kanawha	9	29	4	42	13	7	20	0	1	1	63
Guyandotte	1	1	0	2	3	2	5	0	0	0	7
Twelvepole Cr	0	0	0	0	1	0	1	0	0	0	1
Big Sandy	7	11	1	19	5	3	8	0	1	1	28
Little Sandy & Tygarts Creek	2	0	0	2	1	0	1	0	0	0	3
Scioto	6	14	1	21	14	5	19	1	0	1	41
Little Miami	4	1	0	5	5	0	5	0	0	0	10
Licking	4	4	0	8	4	1	5	0	0	0	13
Great Miami	8	13	0	21	7	5	12	1	0	1	34
Kentucky	2	20	2	24	6	4	10	1	0	1	35
Salt	3	4	0	7	3	0	3	0	0	0	10
Green	5	19	6	30	13	0	13	0	1	1	44
Wabash	20	11	2	33	26	9	35	0	1	1	69
White	18	12	0	30	24	5	29	1	0	1	60
Patoka	0	0	0	0	1	0	1	0	1	1	2
Little Wabash	2	3	0	5	6	1	7	0	0	0	12
Saline	1	1	0	2	3	0	3	0	0	0	5
Tradewater	1	1	0	2	0	0	0	0	0	0	2
Cumberland	8	55	5	68	22	7	29	1	1	2	99
Raccoon Creek	1	4	1	6	4	0	4	0	0	0	10
Ohio Brush	1	0	0	1	1	0	1	0	0	0	2
Ohio Main Stem	16	20	7	43	38	15	53	1	1	2	98
TOTALS	160	318	47	525	268	87	355	9	12	21	901

TOTAL ENTIRE BASIN 901

(1) There are no stations in this class with only recording equipment.

TABLE 7

LENGTH OF DISCHARGE RECORDS
AT GAGING STATIONS IN THE OHIO RIVER BASIN

Sub-Basin	Longest Record (Years)	Number of Station Records for Decades Indicated; Beginning to 1959: 50 Years or Over	40-49	30-39	20-29	10-19	0-9	Total
Allegheny	56	4	3	0	22	7	5	41
Monongahela	52	2	6	9	9	16	3	45
Beaver	48	0	4	5	4	6	0	19
Muskingum	40	0	1	10	22	3	2	38
Little Kanawha	31	0	0	2	5	0	1	8
Hocking	44	0	1	0	2	0	3	6
Kanawha	82	2	1	17	10	4	4	38
Guyandotte	32	0	0	2	1	0	0	3
Twelvepole Cr	17	0	0	0	0	1	0	1
Big Sandy	33	0	0	3	7	3	1	14
Little Sandy	21	0	0	0	1	0	0	1
Tygarts Creek	19	0	0	0	0	1	0	1
Scioto	39	0	0	8	5	5	2	20
Little Miami	36	0	0	2	0	0	5	7
Licking	33	0	0	1	5	2	1	9
Great Miami	46	0	8	4	4	2	3	21
Kentucky	52	1	0	3	8	4	8	24
Salt	21	0	0	0	5	2	7	14
Green	33	0	0	1	12	5	8	26
Wabash	48	0	5	17	18	35	30	105
Saline	20	0	0	0	1	0	0	1
Tradewater	19	0	0	0	0	1	1	2
Cumberland	58	1	1	6	9	23	15	55
Other Lesser Tributaries	44	0	2	6	3	12	5	28
Tributary Total Excluding Tennessee Riv	82	10	32	96	153	132	104	527
Main Stem Ohio	31	0	0	2	8	3	0	13

TABLE 8

ANNUAL RUNOFF - MAXIMUM, MINIMUM AND MEAN
AT KEY STATIONS IN THE OHIO RIVER BASIN

Stream & Station	Period of Record	D.A. at Gage	D.A. at Mouth	Mean Discharge at Gage	Inches of Runoff	Mean Discharge Maximum Year (cfs)	Year	Inches of Runoff	Mean Discharge Minimum Year (cfs)	Year	Inches of Runoff
Allegheny Riv, Natrona, Pa	1938-59	11,410	11,700	19,490	23.2	27,810	1956	33.1	13,950	1954	16.6
Monongahela Riv, Braddock, Pa	1939-59	7,337	7,400	12,480	23.1	16,770	1951	31.0	6,946	1954	12.9
Beaver Riv, Wampum, Pa	1932-59	2,235	3,130	2,365	14.4	3,995	1956	24.3	834	1934	5.0
Muskingum Riv, McConnelsville, O	1921-59	7,411	8,040	7,282	13.3	11,730	1937	21.5	2,660	1931	4.9
Little Kanawha Riv, Palestine, W Va	1928-31; 1939-59	1,515	2,320	2,100	18.8	3,216	1950	28.8	1,075	1947	9.6
Hocking Riv, Athens, O	1915-62	944	1,190	978	14.1	1,520	1927	21.8	233	1954	3.4
Kanawha Riv, Charleston, W Va	1939-59	10,419	12,200	14,320	18.7	20,800	1958	27.2	8,783	1941	11.4
Twelvepole Cr, Wayne, W Va	1915-59	291	441	326	15.2	532	1950	24.8	153	1954	7.1
Little Sandy Riv, Grayson, Ky	1938-62	402	724	484	16.3	959	1950	32.7	120	1954	4.1
Tygarts Cr, Greenup, Ky	1940-62	242	336	304	17.0	546	1950	30.7	68	1954	3.8
Guyandotte Riv, Branchland, W Va	1928-59	1,226	1,670	1,573	17.4	2,309	1935	25.5	573	1941	6.4
Big Sandy Riv, Louisa, Ky	1938-62	3,892	4,280	4,228	14.7	6,423	1950	22.4	1,423	1941	5.0
Scioto Riv, Higby, O	1930-59	5,129	6,510	4,370	11.6	6,742	1937	17.8	1,364	1954	3.7
Little Miami Riv, Milford, O	1915-17; 1925-36; 1938-62	1,195	1,760	1,205	13.7	1,890	1933	21.4	301	1954	3.4
Licking Riv, Catawba, Ky	1928-62	3,300	3,670	4,131	17.0	7,270	1950	29.9	994	1954	4.1
Great Miami Riv, Hamilton, O	1931-62	3,639	5,400	3,203	11.9	6,390 5,144	1913 1950	23.8 19.2	931	1941 1954	3.6 3.5
Whitewater Riv, Brookville, Ind	1923-62	1,239	1,493	1,274	14.0 12.4	2,359	1950 1950	25.8 24.0	271	1941	3.0 3.2
Kentucky Riv, Lockport, Ky	1925-62	6,180	6,970	8,247	18.1	14,600	1927	32.0	2,597	1954	5.7
Salt Riv, Shepherdsville, Ky	1938-62	1,197	2,890	1,533	17.4	3,044	1950	34.5	379 345	1941 1954	4.2 3.8
Rolling Fork, Boston, Ky	1938-62	1,290	1,470	1,691	17.8 17.6	3,364	1950	35.3 34.9	494 473	1954 1941	5.2 5.0 4.6
Green Riv, Livermore, Ky	1930-62	7,564	9,230	10,850	19.5	21,420	1950	38.4	3,390	1931	6.1
Wabash Riv, Mt. Carmel, Ill	1927-59	28,600	33,100	26,980	12.8	56,740	1950	26.9	6,144	1941	2.9
Little Wabash Riv, Carmi, Ill	1939-59	3,090	3,320	2,587	11.4 12.7	6,094	1950	26.8	151	1954	0.6
White Riv, Petersburg, Ind	1927-59	11,139	11,400	11,630	14.3	22,760	1950	27.7	2,138	1941	2.6
Saline Riv, Junction, Ill	1939-59	1,040	1,170	1,211	15.8	1,947	1945	25.4	107	1941	1.4
Tradewater Riv, Olney, Ky	1940-62	255	1,000	328	17.5	692	1950	36.8	62	1941	3.3
Cumberland Riv, Smithland, Ky	1939-42	17,913	17,920	27,920	21.2	44,500	1950	34.8	10,920	1941	8.2
Tennessee Riv, Paducah, Ky	1889-1960	40,200	40,910	63,790	21.5	94,400	1950	31.9	33,080	1941	10.5
Ohio Riv, Metropolis, Ill	1928-60	203,000	203,940	258,500	17.3	443,500	1950	29.7	118,900	1941	8.0

NOTE: $\text{Inches of Runoff Per Year} = \frac{\text{Average Annual Discharge (cfs)}}{\text{Drainage Basin (sq mi)}} \times 13.574$

TABLE 9

FLOW OF SELECTED STREAMS - OHIO RIVER BASIN

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Period of Record	Average Discharge for Period of Record (cfs)	Average Discharge for Period of Record (1000 AF/Yr)	Instantaneous Maximum Discharge (cfs)	Instantaneous Maximum Discharge Date	Instantaneous Minimum Discharge (cfs)		Instantaneous Minimum Discharge Date	Consecutive 7 Day Minimum Discharge (cfs)	Consecutive 7 Day Minimum Discharge Period	Selected 7 Day - 10 Year Low Flows (cfs)(12)
	ALLEGHENY RIVER BASIN												
1-1	Allegheny Riv, Eldred, Pa	550	1939-59	966	699	55,000	7-19-42	22	(2)	9-(29,30)-59	24.6	9-(24-30)-59	25
1-2	Allegheny Riv, Red House, N Y	1,690	1903-59	2,792	2,021	49,100	3-8-56	80	(5)	12-(15-17)-08			115
1-4	Conewango Riv, Russell, Pa	816	1939-59	1,470	1,064	14,400	4-7-47	58	(2)	10-(1,2)-41	59.4	(9-26)-(10-2)-41	
1-7	French Cr, Utica, Pa	1,028	1932-59	1,733	1,255	20,700	3-(23,24)-48	43	(2)	7-30-34	48	(8-27)-(9-2)-33	
1-8	Allegheny Riv, Franklin, Pa	5,982	1914-59	10,320	7,471	138,000	3-13-20	334	(2)	7-30-34	415	9-(14-20)-32	470
1-9	Clarion Riv, Cooksburg, Pa	807	1938-59	1,448	1,048	32,700	7-19-42	41	(2)	8-30-39			55
1-10	Allegheny Riv, Kittanning, Pa	8,973	1904-28; 1934-59	15,710	11,373	269,000	3-26-13	570	(7)	9-(15-17)-13	610	9-(11-17)-13	750
1-11	Conemaugh Riv, Tunnelton, Pa	1,358	1939-59	2,352	1,703	59,200	3-7-45	1	(2)	9-10-54			234
1-13	Kiskiminetas Riv, Vandergrift, Pa	1,825	1937-59	3,032	2,195	71,900	3-31-40	56	(2)	10-(15,16)-52			219
1-14	Allegheny Riv, Natrona, Pa	11,410	1938-55	19,490	14,110	238,000	12-30-42	922	(2)	9-3-57			1,096
1-15	Little Mahoning Cr, McCormick, Pa (13)	87.4	1939-63	149.0	107.8	5,300	1-27-52	0.3		9-28-59	0.7	1959	1
	MONONGAHELA RIVER BASIN												
2-2	Tygart Valley Riv, Belington, W Va	408	1907-59	789	571	18,400	7-25-12	0.1	(2)	9-13-30	0.2	9-(13-19)-30	4.2
2-3	Tygart Valley Riv, Philippi, W Va	916	1940-59	1,824	1,321	33,600	10-16-54	4.9	(2)	10-(10-12,21)-53	5.2	10-(16-22)-53	8
2-4	Tygart Valley Riv, Colfax, W Va	1,366	1939-59	2,607	1,887	22,500	2-14-48	94	(2)	7-3-46	132	5-(1-7)-41	192
2-8	West Fork Riv, Enterprise, W Va	759	1907-18; 1932-59	1,170	847	31,400	2-14-48	3.4	(2)	7-27-34	6.4	10-(16-22)-39	11
2-9	Monongahela Riv, Hoult, W Va	2,388	1915-26; 1938-59	4,120	2,983	91,500	1-2-19	33	(2)	10-2-17	41	10-(14-20)-23	99
2-10	Cheat Riv, Parsons, W Va	718	1913-59	1,656	1,199	52,100	10-15-54	9	(2)	8-12-30	11.1	10-(9-15)-30	33
2-11	Cheat Riv, Rowlesburg, W Va	972	1923-59	2,222	1,609	66,300	10-16-54	10	(2)	10-15-30			
2-12	Cheat Riv, Pisgah, W Va	1,354	1927-58	2,988	2,163	127,000	10-16-54	13	(2)	10-15-53	14	10-(12-18)-53	
2-13	Monongahela Riv, Greensboro, Pa	4,407	1938-59	8,168	5,913	140,000	10-16-54	204	(5)	9-(1-3,5)-46	267	11-(4-10)-53	384
2-16	Youghiogheny Riv, Youghiogheny Riv Dam, Pa	463	1939-59	850	615	13,700	3-5-48	(No Flow)		(5,6)-50		5-(22-29)-50	
2-17	Youghiogheny Riv, Connellsville, Pa	1,326	1908-59	2,503	1,812	103,000	10-16-54	11	(2)	9-(23,26,27)-08	13.6	10-(22-28)-08	
2-19	Redstone Cr, Waltersburg, Pa (13)	73.7	1942-63	99.9	72.3	4,400	10-15-54	4.2		8-2-62	12.3	1953	75
2-20	Big Piney Run, Salisbury, Pa (13)	24.5	1932-63	37.9	28.4	6,850	10-15-54	0.08		9-1-53	1.0	1957	13
2-21	Greenlick Run, Greenlick Res, Pa (13)	3.0	1941-63	5.4	3.9	1,400	8-13-43	0.04		10-3-57	0.07	1957	0.07
2-22	Elk Cr, Mouth (13)	84.6		124	89.7			0.2		9-14-52			
2-23	Blackwater Riv, Mouth (13)	86.2		193	139.7	7,170	3-29-24	1.5		9-(11,12)-59			
2-24	Youghiogheny Riv, Friendsville, Md	295	1934-59	647	468	13,000	10-16-54	10	(2)	9-8-57			54.5
	BEAVER RIVER BASIN												
3-3	Mahoning Riv, Youngstown, Ohio	899	1921-62	844	611	17,600	1-25-37	28	(2)	8-14-30			120
3-4	Mahoning Riv, Lowellville, Ohio	1,076	1942-62	1,078	780	21,000	1-21-59	125	(2)	6-29-52			
3-5	Shenango Riv, Sharpsville, Pa	588	1938-59	743	538	15,700	1-22-59	38	(2)	9-4-41			86
3-6	Beaver Riv, Wampum, Pa	2,235	1914-18; 1932-59	2,365 (adj)	1,712	50,100	5-28-46	74	(2)	7-30-33			232
3-8	Mahoning Riv, Alliance, Ohio (13)	87.9	1941-63	82.0	59.4	9,740	1-21-59	(No Flow)		Often			
3-9	Mill Cr, Berlin Center, O (13)	19.0	1941-63	17.6	12.7	1,900	5-27-46	(No Flow)		Often			
3-10	Kale Cr, Princetown, Ohio (13)	21.9	1940-63	21.1	15.3	3,890	1-21-59	(No Flow)		1952,53,54,55,62,63			
3-11	Little Shenango Riv, Greenville, Pa (13)	104.0	1913-63	139.0	100.6	8,540	1-22-59	2.9		7-31-34	3.4	1934	5.3
	MUSKINGUM RIVER BASIN												
4-2	Mohican Riv, Greer, Ohio	942	1921-62	879	636	17,700	8-7-35	50est	(2)	1-2-35			
4-3	Walhonding Riv, Nellie, Ohio	1,502	1921-59	1,457	1,055	43,800	1-25-37	3.3	(2)	10-20-39	163	10-(14-20)-39	
4-7	Tuscarawas Riv, below Dover Dam, nr Dover, Ohio	1,398	1923-62	1,375	995	26,400	1-26-37	2.3	(2)	7-20-46; 10-27-48			159

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Period of Record	Average Discharge for Period of Record (cfs)	Average Discharge for Period of Record (1000 AF/Yr)	Instantaneous Maximum Discharge (cfs)	Instantaneous Maximum Discharge Date	Instantaneous Minimum Discharge (cfs)	Instantaneous Minimum Discharge Date	Consecutive 7 Day Minimum Discharge (cfs)	Consecutive 7 Day Minimum Discharge Period	Selected 7 Day - 10 Year Low Flows (cfs) (12)
	MUSKINGUM RIVER BASIN (Cont'd)											
4-8	Tuscarawas Riv, Newcomerstown, Ohio	2,436	1921-62	2,422	1,768	46,800	1-26-37	120 (2)	8-7-30			210
4-9	Muskingum Riv, nr Coshocton, Ohio	4,847	1936-62	4,855	3,515	78,700	1-26-37	342 (2)	11-4-44	454		464
4-11	Licking Riv, Toboso, Ohio	672	1903-05; 1921-59	672	487	49,800	1-22-59	34 (2)	1-1-34	48	(7-30)-(8-5)-30	50
4-13	Muskingum Riv, McConnellsville, O	7,411	1921-59	7,282	5,272	126,000	1-26-37	218 (2)	8-25-50	305	8-(20-26)-30	565
4-14	Mid Br Nimishillen Cr, Canton, Ohio (13)	44.2	1941-63	32.3	23.4	2,470	1-22-59	0.2	9-19-62; 11-9-44			
4-15	Home Cr, New Philadelphia, O (13)	1.6	1936-63	1.2	0.9	299	9-4-61	(No Flow)	Often	(No Flow)		(No Flow)
4-16	Mill Cr, Coshocton, O (13)	27.5	1936-63	27.6	20.0	7,650	6-28-57	(No Flow)	9-(28,29)-54 8-(29,31)-62			
	LITTLE KANAWHA RIVER BASIN											
5-1	Little Kanawha Riv, Glenville, W Va	386	1928-59	601	435	20,400	4-16-39	(No Flow)	(9,10)-30 (9,10)-32			
5-4	Little Kanawha Riv, Palestine, W Va	1,515	1939-59	2,100	1,520	53,000	4-17-39	0.6 (8)	7-14-59	1.4 (8)	7-(15-21)-59	36
5-5	Hughes Riv, Cisko, W Va	452	1928-31; 1938-59	584	423	31,700	6-26-50	(No Flow)	8-(2-6)-30	(No Flow)	9-(4-10)-30	
	HOCKING RIVER BASIN											
6-1	Hocking Riv, Enterprise, Ohio	460	1930-62	435	315	25,200	4-20-40	12 (2)	8-19-32	28.6 (7)	8-(8-14)-32	
6-6	Hocking Riv, Athens, Ohio	944	1915-62	978	708	30,400	3-7-45	9 (2)	10-11-30	13.6 (7)	10-(11-17)-30	36
6-7	Clear Cr, Rockbridge, Ohio (13)	87.7	1939-63	83.9	60.6	16,000	7-22-48	3.0	12-29-47	6.3		8
	KANAWHA RIVER BASIN											
7-1	New Riv, Galax, Va	1,131	1929-59	1,801	1,304	141,000	8-14-40	193 (9)	1-9-56			359
7-8	New Riv, Glenlyn, Va	3,768	1927-59	4,929	3,568	226,000	9-13-1878	770 (2)	9-8-30			1,050
7-10	Greenbrier Riv, Alderson, W Va	1,357	1895-1959	1,993	1,443	77,500	3-14-18	24 (2)	8-12-30; 10-(1,2)-30			42
7-13	Bluestone Riv, Pipestem, W Va	363	1950-59	466	337	16,100	1-29-57	7.0 (2)	9-(21-23,30)-55			
7-14	New Riv, Bluestone Dam	4,604	1923-59	5,536	4,008	232,000	8-15-40	10 (10)	8-30-48			
7-15	Gauley Riv, nr Summersville, W Va	680	1908-16; 1928-59	1,536	1,112	77,700	7-4-32	0.6 (2)	10-27-53			5.5
7-17	Chestnut Cr, Galax, Va (13)	39.0	1944-64	66.6	48.2	6,980	10-17-47	13	1-5-56	15.1	9-(13-19)-54	23
7-18	Kanawha Riv, Kanawha Falls, W Va	8,367	1877-1959	12,580	9,108	320,000	9-14-78	640 (2)	8-15-30			
7-21	Elk Riv, Queen Shoals, W Va	1,145	1928-59	1,951	1,412	72,000	7-5-32	0.3 (2)	11-(4,5)-53			6.2
7-22	Kanawha Riv, Charleston, W Va	10,419	1939-59	14,320	10,367	216,000	8-15-40	1,030 (2)	10-(1-5)-53			1,285
7-23	Little Coal Riv, Danville, W Va	270	1930-59	337	244	42,800	2-3-39	(No Flow)	(7,10)-30			
7-29	S Fk New Riv, Jefferson, N C	207	1924-59	411	297	52,800	8-14-40	65 (2)	9-9-25	86.0	8-(14-20)-30	89
	BIG SANDY RIVER BASIN											
8-5	Levisa Fork, Paintsville, Ky	2,143	1915-15; 1928-62	2,385	1,727	69,700	1-31-57	8.4 (2)	7-(23-25)-30			15
8-8	Tug Fork, Kermit, W Va	1,185	1934-62	1,332	964	61,300	1-30-57	23 (2)	10-14-39			26
8-9	Big Sandy Riv, Louisa, Ky	3,892	1938-62	4,228	3,061	89,400	3-2-55	(6)				59
	LITTLE SANDY RIVER BASIN											
8-10	Little Sandy Riv, Grayson, Ky	402	1938-62	484	350	24,500	9-22-50	1.5 (5)	10-12-53			2.7
	TYGARTS CREEK BASIN											
8-11	Tygarts Cr, Greenup, Ky	242	1940-62	304	220	14,800	2-29-62	(No Flow)				
	GUYANDOTTE RIVER BASIN											
8-14	Guyandotte Riv, Branchland, W Va	1,226	1928-59	1,573	1,139	40,400	1-30-57	3.6 (2)	10-25-30			20
	TWELVEPOLE CREEK BASIN											
8-15	Twelvepole Cr, Wayne, W Va	291	1915-59	326	236	22,000 15,900	2-4-39 2-28-62	(No Flow)	10-(21-27)-53; 11-2-53	(No Flow)	10-(21-27)-53	
	SCIOTO RIVER BASIN											
9-1	Scioto Riv, nr Prospect, Ohio	571	1925-32; 1940-62	449	325	10,100	3-22-27; 1-21-59	3.5 (2)	9-13-53	7.1 (7)	9-(14-20)-32	7.9

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	SCIOTO RIVER BASIN (Cont'd)											
9-2	Scioto Riv, below O'Shaughnessy Dam, nr Dublin, Ohio	988	1921-62	768	556	55,200	1-22-59	0.4 (2)	11-8-24	4 (7)	11-(6-12)-24	8.2
9-3	Olentangy Riv, Delaware, Ohio	387	1923-34; 1938-59	348	252	14,100	3-21-27	0.1 (2)	8-20-30	0.1 (7)	9-(14-20)-34	1.0
9-5	Scioto Riv, Columbus, Ohio	1,624	1920-62	1,336	967	68,200	1-22-59	42 (2)	9-6-30	53 (7)	9-(5-11)-30	57.8
9-7	Big Walnut Cr, Rees, Ohio	544	1921-35; 1938-62	487	353	59,800	1-22-59	5 (2)	9-(4,5)-25; 9-(10-12)-25	7.6 (7)	9-(6-12)-25	7.0
9-8	Big Darby Cr, Darbyville, Ohio	533	1921-35; 1938-59	438	317	49,000	1-22-59	1.4 (2)	9-17-32	2.6 (7)	9-(14-20)-32	6.2
9-11	Scioto Riv, Chillicothe, Ohio	3,847	1920-62	3,294	2,385	144,000	1-23-59	160 (2)	1-1-31	188 (7)	(9-29)-(10-5)-30	184.5
9-12	Paint Cr, Bourneville, Ohio	808	1921-36; 1938-62	788	570	52,100	3-6-45 (14)	6.7 (2)	8-(13,14)-30	7.6 (7)	10-(5-11)-30	7.8
9-13	Scioto Riv, Higby, Ohio	5,129	1930-59	4,370	3,164	177,000	1-23-37	244 (2)	10-23-30	255 (7)	10-(19-25)-30	
9-16	Little Scioto Riv, Marion, Ohio (13)	70.0	1938-63	49.7	36.0	5,160	1-22-59	(No Flow)	Often	(No Flow)		(No Flow)
	GREAT MIAMI RIVER BASIN											
10-3	Mad Riv, nr Springfield, Ohio	485	1904-06; 1914-59	680	492	30,500	1-21-59	30	9-15-04			
10-4	Mad Riv, Dayton, Ohio	632	1914-62	622	450	21,200	1-22-59	91 (2)	8-(6,9)-34			224
10-7	Greenville Cr, nr Bradford, Ohio	195	1930-62	170	123	9,320	5-14-33	6.7 (2)	8-(4,5)-34			
10-9	Great Miami Riv, Taylorsville, Ohio	1,155	1914-17; 1921-62	995	720	31,400	1-22-59	30 (2)	1-2-45	39	(9-26)-(10-2)-41	46
10-10	Great Miami Riv, Dayton, Ohio	2,513	1929-62	2,083	1,508	60,900	1-22-59	78 (2)	9-26-41	117	(9-25)-(10-1)-41	175
10-12	Great Miami Riv, Hamilton, Ohio	3,639	1931-62	3,203	2,319	352,000	3-26-13	100 (2)	9-(26,27)-41	201	(9-26)-(10-2)-41	281
10-18	E Fk Whitewater Riv, Brookville, Ind	382	1954-59	423	306	36,100	1-21-59	12 (2)	9-5-55	19	9-(14-20)-55	19
10-19	Whitewater Riv, Alpine, Ind	539	1928-59	545	395	35,000	1-14-37	14 (2)	9-22-31	33.1	8-(2-8)-34	45
10-20	Whitewater Riv, Brookville, Ind	1,239	1915-17; 1923-62	1,274	922	81,800	1-21-59	49 (2)	1-5-35	77.5	10-(12-18)-34	82
	MILL CREEK BASIN											
10-14	Mill Cr, Carthage, Ohio	116	1946-62			8,900	1-21-59	(No Flow)	1948-49			
10-21	Mill Cr, Reading, Ohio (13)	73.1	1938-63			5,780	3-6-45	(No Flow)	For Days in 1940,41,44,51			
	LITTLE MIAMI RIVER BASIN											
10-15	Little Miami Riv, Milford, Ohio	1,195	1915-17; 1925-36; 1938-62	1,205	872	84,100	1-22-59	27 (2)	9-18-54	38.8	[illegible]-(13-19)-54	42
10-16	E Fk Little Miami Riv, Perintown, Ohio	477	1915-17; 1925-62	547	396	39,400	3-6-45 (15)	0.3 (2)	7-24-30	0.6	7-(20-26)-30	0.7
	KENTUCKY RIVER BASIN											
11-2	N Fk Kentucky Riv, Jackson, Ky	1,101	1928-31; 1936-37; 1938-62	1,293	936	53,500	1-30-57	(No Flow)	2-4-39			2.2
11-3	M Fk Kentucky Riv, Tallega, Ky	537	1930-32; 1939-62	700	507	52,700	1-30-57	0.1 (2)	10-(12-22)-53	0.1	10-(12-18)-53	
11-4	S Fk Kentucky Riv, Booneville, Ky	722	1925-31; 1939-62	1,028	744	66,100	1-30-57	(No Flow)	11-(3-14)-53	(No Flow)	10-(11-17)-53	33
11-5	Kentucky Riv, Lock 10, nr Winchester, Ky	3,955	1907-62	5,223	3,781	92,400	2-5-39	10est (2)	10-30			
11-8	Kentucky Riv, Frankfort, Ky	5,412	1905-06; 1925-62	7,023	5,085	115,000	1-25-37	(6)				112
11-9	Elkhorn Cr, Frankfort, Ky	473	1915-20; 1939-62	599	434	22,400	4-14-48	(No Flow)	1-(7-13)-40	(No Flow)	1-(7-13)-40	163
11-10	Kentucky Riv, Lock 2 Lockport, Ky	6,180	1925-62	8,247	5,971	125,000	1-26-37	(6)				
	SALT RIVER BASIN											
11-11	Beech Fork, Bardstown, Ky	669	1939-62	890	644	27,900	2-28-59	(No Flow)	(9,10)-48; (8,9)-57	(No Flow)	(9-29)-(10-4)-48	0.04
11-12	Rolling Fork, nr Boston, Ky	1,299	1938-62	1,720	1,245	41,300	2-15-48	0.4 (2)	(9,10)-53; 10-20-39	0.4	10-(6-12)-53	1.3
11-13	Salt Riv, Shepherdsville, Ky	1,197	1938-62	1,533	1,110	57,700	5-9-61	(No Flow)		(No Flow)	9-(21-27)-53	
	LICKING RIVER BASIN											
11-14	Licking Riv, Farmers, Ky	831	1915-20; 1928-31; 1936-37; 1938-62	1,076	779	24,000	2-28-62	0.7 (2)	10-14-30	0.9	10-(13-19)-30	3.1
11-15	Licking Riv, McKinneysburg, Ky	2,326	1924-26; 1938-62	3,038	2,199	54,100	3-13-48	3.8 (2)	10-(18,19)-52	4.8	10-(20-26)-53	
11-17	S Fk Licking Riv, Cynthiana, Ky	621	1933-62	751	544	35,300	3-13-48	0.3 (2)	10-(23-26)-53	0.3	11-(10-16)-53	0.7
11-18	Licking Riv, Catawba, Ky	3,300	1914-20; 1928-62	4,131	2,991	86,300	3-14-48	2.5 (2)	10-(14,18)-30	3.3	10-(15-21)-30	10.3
11-19	Triplett Cr, Morehead, Ky (13)	47.9	1941-65	73.4	53	44,000	7-5-39	0.5	7-25-60	0.5	7-(25-31)-60	0.5

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	GREEN RIVER BASIN												
12-1	Green Riv, Greensburg, Ky	736	1939-62	1,086	786	60,600	2-28-62	0.4	(2)	10-(26,27)-53	0.5	10-(21-27)-53	1.7
12-2	Nolin Riv, Wax, Ky	600	1936-62	790	572	22,000	1-24-37	34	(2)	9-17-41	39	10-(17-23)-53	45
12-4	Green Riv, Brownsville, Ky	2,762	1924-31; 1936-37; 1938-62	4,136	2,994	120,000	1-24-37	120	(2)	9-(18,19)-54	137	9-(13-19)-54	141
12-5	Barren Riv, Bowling Green, Ky	1,848	1938-62	2,464	1,784	85,000	2-28-62	44	(2)	2-(19,20)-54	47	9-(13-19)-54	53
12-7	Green Riv, Lock 4, Woodbury, Ky	5,403	1936-37; 1937-62	7,979	5,645	205,000	1-25-37	200	(2)	9-(14-16)-54	207	9-(11-17)-54	241
12-8	Rough Riv, Dundee, Ky	757	1939-62	963	697	20,000	1-14-50	8.1	(2)	9-(19,20)-41	11.1	10-(8-14)-53	
12-9	Green Riv, Lock 2, Calhoun, Ky (formerly Green Riv at Livermore, Ky)	7,564	1930-62	10,850	7,855	208,000	1-27-37	280	(2)	10-(5-9,23-27)-30; 2-(2-4)-31	291	10-(21-27)-30	306
	WABASH RIVER BASIN												
13-1	Wabash Riv, Bluffton, Ind	506	1930-59	403	292	11,800	2-15-50	3.9	(2)	7-18-36	4.2	7-(16-22)-36	4.7
13-9	Wabash Riv, Wabash, Ind	1,733	1923-59	1,511	1,094	49,600	5-18-43	17	(2)	8-(4,5,9)-34; 7-(21,22)-36	17.7	8-(3-9)-34	26
13-10	Wabash Riv, Logansport, Ind	3,751	1923-59	3,317	2,401	89,800	5-18-43	97	(6)	9-25-41	142	9-(29-30)-41	190
13-11	Tippecanoe Riv, nr Delphi, Ind	1,857	1939-50	1,601	1,159	22,600	2-10-59	1.0	(3)	11-(2-3)-54	64.6	11-(2-8)-54	188
13-15	Wabash Riv, Lafayette, Ind	7,247	1923-59	6,401	4,634	131,000	5-19-43	265	(2)	1-12-54	404	9-(21-27)-41	535
13-21	Vermilion Riv, Danville, Ill	1,280	1914-21; 1928-59	897	649	48,700	3-13-39	2.0	(2)	8-10-30	2.1	10-(8-14)-20	15
13-22	Wabash Riv, Montezuma, Ind	11,100	1927-59	9,492	6,872	184,000	5-20-43	510	(2)	1-12-54	600	10-(16-22)-54	775
13-23	Wabash Riv, Terre Haute, Ind	12,200	1927-59	10,440	7,558	189,000	5-20-43	690	(2)	8-10-34	732	9-(24-30)-41	900
13-24	Wabash Riv, Riverton, Ind	13,100	1938-59	11,442	8,284	201,000	5-21-43	858	(2)	9-(27-30)-41; 10-1-41	870	(9-25)-(10-1)-41	1,040
13-25	Wabash Riv, Vincennes, Ind	13,700	1929-59	11,550	8,362	189,000	5-(22-23)-43	770	(2)	8-(4,5)-34	799	8-(3-9)-34	1,060
13-27	Embarrass Riv, Ste Marie, Ill	1,540	1909-13; 1914-59	1,227	888	44,800	1-4-50	1	(2)	10-(5-9)-14	1.9	9-(13-19)-54	16
13-30	White Riv, Noblesville, Ind	814	1915-26; 1928-59	821	594	27,200	3-21-27	36	(2)	9-25-41	42	9-(24-30)-41	58
13-31	White Riv, Indianapolis, Ind	1,627	1904-06; 1930-59	1,411	1,021	37,200	5-18-43	6.8	(2)	9-21-41	11.5	9-(24-30)-41	105
13-33	White Riv, Spencer, Ind	2,980	1925-59	3,076	2,227	59,400	5-15-33	133	(2)	9-(25,30)-41	137.0	(9-25)-(10-1)-41	210
13-34	Eel Riv, Bowling Green, Ind	844	1931-59	854	618	34,000	1-4-50	11	(2)	10-(7,8)-54	12.0	10-(4-10)-54	17
13-36	E Fk White Riv, Columbus, Ind	1,692	1947-59	1,981	1,434	48,700	1-28-52	87	(2)	9-29-54; 10-7-54			103
13-37	E Fk White Riv, Seymour, Ind	2,333	1927-59	2,431	1,760	78,500	1-5-49	84	(2)	9-15-41	93	(9-25)-(10-1)-41	155
13-40	E Fk White Riv, Shoals, Ind	4,954	1903-06; 1909-16; 1923-59	5,458	3,951	160,000	3-28-13	44	(4)	10-6-35	168	10-(3-9)-35	222
13-41	White Riv, Petersburg, Ind	11,139	1927-59	11,630	8,420	183,000	1-22-37	533	(2)	10-2-41	598	(9-26)-(10-2)-41	685
13-42	Wabash Riv, Mount Carmel, Ill	28,600	1927-59	26,980	19,533	305,000	5-25-43	1,620	(2)	9-(27,28,30)-41	1,714	(9-25)-(10-1)-41	2,250
13-44	Little Wabash Riv, below Clay City, Ill (formerly Wilcox, Ill)	1,130	1914-59	902	653	47,000	1-5-50	(No Flow)		9-(13-19)-54	(No Flow)	9-(3-9)-54	0.55
13-46	Little Wabash Riv, Carmi, Ill	3,090	1939-59	2,587	1,873	39,400	1-11-50	0.6	(2)	9-9-53; 7-31-54	1.5	9-(6-12)-53	5.2
13-49	Youngs Cr, Edinburg, Ind (13)	109	1942-63	109	78.9	10,700	1-27-52	0.4		9-14-54	0.7	10-(19-25)-53	0.9
13-50	Vernon Fork, *Butlerville, Ind (13)*	*87.3*	*1942-63*	*97*	*70.1*	*26,200*	*1-21-59*	*(No Flow)*		*Often*	*(No Flow)*	*(10-29)-(11-4)-44*	*0.1*
	CUMBERLAND RIVER BASIN												
14-1	Cumberland Riv, Barbourville, Ky	960	1922-31; 1948-62	1,722	1,246	47,900	5-31-27	0.2	(7)	10-5-30			8.3
14-3	Cumberland Riv, Cumberland Fall, Ky	1,977	1907-11; 1914-62	3,146	2,278	59,600	1-28-18	4	(2)	9-19-54			16
14-4	New Riv, New River, Tenn	382	1934-59	708	513	44,300	2-3-39	(No Flow)		8-(12-15)-44			
14-5	S Fk Cumberland Riv, *Stearns, Ky*	*954*	*1942-62*	*1,767*	*1,279*	*69,600*	*2-13-48*	*11*	*(2)*	*9-(17-20)-54*			
14-7	Cumberland Riv, nr Rowena, Ky	5,790	1939-62	8,867	6,420	162,000	1-9-46	(No Flow)					
14-9	Obey Riv, Dale Hollow Dam, Tenn	935	1938-58	1,395	1,010	41,400	2-4-39		(6)				
14-10	Cumberland Riv, Celina, Tenn	7,320	1922-59	11,220	8,123	145,000	12-29-26	69	(7)	9-(2,11-14, 26)-25			
14-13	Collins Riv, McMinnville, Tenn	624	1924-59	1,126	815	75,300	3-23-29	35	(2)	9-21-30			
14-14	Caney Fork, Rock Island, Tenn	1,640	1911-13; 1913-14; 1914-59	3,193	2,312	210,000	3-23-29	25	(5)	(8-10)-51			

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	CUMBERLAND RIVER BASIN (Cont'd)											
14-15	Cumberland Riv, Carthage, Tenn	10,700	1922-59	17,020	12,322	210,000	12-30-26	366 (5)	10-29-40			
14-21	Stones Riv, Donelson, Tenn	834	1938-59	1,376	996	68,700	1-14-48	10 (2)	9-(21,22, 24)-40			
14-23	Harpeth Riv, Kingston Springs, Tenn	687	1924-59	934	676	60,000	1-7-46	12 (2)	9-18-39			
14-25	Red Riv, Adams, Tenn	678	1920-59	972	704	42,000	1-23-37	30 (2)	9-10-25			
14-27	Cumberland Riv, Dover, Tenn	16,530	1937-59	24,310	17,600	188,000 280,000 (11)	2-15-50; 1-25-37	414 (5)	10-4-47			
14-31	Cumberland Riv, Smithland, Ky	17,913	1939-62	27,920	20,214	201,000	2-18-50	453 (2)	6-23-44			
14-35	Yellow Cr, Middlesboro, Ky (13)	58.2	1940-60	105	76.6	6,160	1-7-46					1.2
14-36	Roaring Riv, Hilham, Tenn (13)	78.7	1931-63	110	80	9,770	3-17-63	1.9	10-(19,24,26, 28)-11-9-40	2.4	9-(13-19)-54	
14-37	Falling Water Riv, Cookeville, Tenn (13)	73.3	1932-56	111	80	5,420	3-22-55	0.9	10-15-36	1.8	10-(19-25)-36	
	LITTLE BEAVER RIVER BASIN											
15-1	Little Beaver Riv, E Liverpool, Ohio	505	1915-62	522	378	25,000	7-19-41	12	1918,30,32,36			
	MIDDLE ISLAND CREEK BASIN											
15-2	Middle Island Cr, Little, W Va	458	1915-59	617	447	25,000	6-26-50	(No Flow)	(9-1)-(11-4)-30; 11-(7-10)-30	(No Flow)	10-(1-6)-30	
	RACCOON CREEK BASIN											
15-3	Raccoon Cr, Adamsville, Ohio	587	1915-35; 1938-62	655	474	15,500	4-15-48	1.4 (2)	9-24-30			
	OHIO BRUSH CREEK BASIN											
15-4	Ohio Brush Cr, West Union, Ohio	388	1926-35; 1940-62	442	320	51,600	3-19-43	(No Flow)	9-(13-23, 27,28)-55			0.6
	BLUE RIVER BASIN											
15-5	Blue Riv, Whitecloud, Ind	461	1930-59	617	447	28,500	1-22-59	9.2 (2)	10-1-41	11.4	10-(15-21)-53	12
	SALINE RIVER BASIN											
15-6	Saline Riv, Junction, Ill	1,040	1939-59	1,211	877	37,400	3-19-45	0.9 (2)	9-(22,23)-44			
	TRADEWATER RIVER BASIN											
15-7	Tradewater Riv, Olney, Ky	255	1940-62	328	237	7,960	11-19-57	(No Flow)				

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Period of Record	Average Discharge for Period of Record (cfs)	Average Discharge for Period of Record (1000 AF/Yr)	Instantaneous Maximum Discharge (cfs)	Instantaneous Maximum Discharge Date	Instantaneous Minimum Discharge (cfs)	Instantaneous Minimum Discharge Date	30 Consecutive Day Average Discharge 10 Year Frequency: Natural (cfs)	30 Consecutive Day Average Discharge 10 Year Frequency: Modified (cfs) (Group 1963 A Res)
	OHIO RIVER BASIN										
	Ohio Riv,										
15-B	Sewickley, Pa	19,500	1933-59	32,740	23,703	574,000	3-18-36	1,800	9-4-57	2,370	5,580
15-E	Bellaire, Ohio	25,100	1941-58	40,850	29,575	412,000	12-31-42				
15-F	St. Marys, W Va	26,850	1938-59			421,000	1-1-43				
15-H	Parkersburg, W Va	35,600	1940-59	50,730	36,750	440,000	1-1-43	2,290 (daily)	10-1-55	3,590	7,520
15-K	Pomeroy, Ohio	40,500	1936-37; 1940-59			554,000	1-27-37				
15-L	Point Pleasant, W Va	52,760	1940-59			522,000	1-1-43				
15-M	Huntington, W Va	55,900	1934-59	77,620	56,200	654,000	1-28-37	3,200 (daily)	9-(6,13)-34 11-2-34	4,800	9,640
15-N	Ashland, Ky	60,750	1938-59			589,000	4-16-48	3,760 (daily)	10-2-46		
15-P	Maysville, Ky	70,130	1940-62	91,550	66,300	635,000	4-17-48			5,795	10,750
15-Q	Cincinnati, Ohio	76,580	1936-62	96,810	70,000	894,000	1-26-37			6,250	11,450
15-R	Louisville, Ky	91,170	1928-62	113,700	82,300	1,110,000	1-(26,27)-37	2,100 (daily)	8-12-30	7,415	12,450
15-S	Evansville, Ind	107,000	1936-62	133,900	96,941	1,410,000	1-27-37			8,705	16,200
15-T	Golconda, Ill	143,900	1937-62			1,470,000	2-25-37				
15-U	Metropolis, Ill	203,000	1928-62	258,500	187,000	1,780,000	2-1-37	20,600 (daily)	10-8-41	20,233	47,900
15-V	Mississippi Riv, Upstream of Ohio Riv, Thebes, Ill	717,200	1933-37; 1939-45	196,100	134,700	893,000		45,200			

FOOTNOTES:

(1) See Plate 11 for Station Locations.

(2) Natural Flow.

(3) Caused by Repair Work at Oakdale Dam.

(4) Caused by Filling of Williams Reservoir.

(5) Minimum Daily - Natural

(6) Minimum Discharge Not Determined.

(7) Observed Flow.

(8) Due to Filling of Pool Above Lock No. 3.

(9) Result of Freeze-Up.

(10) Construction - Bluestone Dam.

(11) 1916-37 at Lock D, from Unpublished Records of Corps of Engineers.

(12) Data from Various Sources; Period Not Necessarily the Same as Period of Record.

(13) Data Furnished by Soil Conservation Service.

(14) 56,900 cfs - (3-10-64).

(15) 42,400 cfs - (3-10-64).

TABLE 10

OHIO RIVER BASIN INFILTRATION INDICES
(Inches Per Hour)

Sub-Basin and Location	Max Summer	Min Summer	Winter	SDF*	Ohio Basin SPF	Initial Loss Inches (Summer) Winter = 0
Allegheny River Basin					0.01	
Allegheny Reservoir	0.3	0.07	.04 to .12			0.7
Monongahela River Basin					0.01	
					0.02	
Beaver River Basin					0.01	
Shenango Reservoir	0.2	0.06				1.2
Mahoning River Reservoir			0.02 to 0.05	0.02		
West Branch Reservoir	0.2	0.1	0.01			1.5 to 2.5
Muskingum River Basin				0.05	0.02	1.0
Little Kanawha River Basin			.01 to .05	0.05	0.01	1.0
Hocking River Basin				0.05	0.015	1.0
Kanawha River Basin				0.05	0.02	1.0
Summersville Reservoir		.043	.004 to .01	0.04		.84 to 1.3
Twelvepole Creek Basin	0.2 to 0.3	0.05	0.02	0.02	0.01	1.05
Little Sandy River Basin	0.2 to 0.3	0.05	0.02 to 0.4	0.05		1.2
Tygarts Creek Basin				0.05		1.0
Guyandotte River Basin	0.2 to 0.3	0.05	0.02	0.05	0.02	1.2
Big Sandy River Basin	0.2 to 0.3	0.05	0.02	0.05	0.02	1.2
Scioto River Basin	0.05	0	0.02	0.05	0.02	1.0 to 1.2
Mill Creek Basin	0.184	.012	0.01 to 0.08			
West Fork Reservoir			0.005			
Little Miami River Basin				0.05	0.02	1.0
Licking River Basin			0.02 to 0.03		0.01	.50
Great Miami River Basin					0.02	
Whitewater River Sub-Basin	0.03	0.02	0.02	0.04 to 0.05		.20 to .30
Mad River Sub-Basin	0.03	0.02				
Kentucky River Basin			0.02 to 0.03		0.02	.50
Salt River Basin					0.015	
Green River Basin	0.10	0.018	0.02 to 0.04		0.01	
Wabash River Basin					0.01	
Mansfield Reservoir		0.05				0.50
Cagles Mill Reservoir	0.18	0.055	0.009			
Upper Wabash River Basin					0.035	
(Above Peru)						
White River Sub-Basin					0.02	
Little Wabash River Sub-Basin					0.01	
Cumberland River Basin					0.04	
J. Percy Priest Reservoir	0.15	0.02	0.014 to 0.04	0.02		
Wolf Creek Reservoir			0.019 to 0.048			
Wabash River Basin						
E Fk White River Sub-Basin					0.025	

* SDF - Spillway Design Flood

TABLE 11

HYDROLOGIC SOIL GROUPS FOR TYPICAL SOILS IN THE OHIO RIVER BASIN(1)

Soil Name - Soil Group

Abington - B
Aboite - C
Ayrshire - C

Bedford - C
Bewleyville - B
Bloomfield - A
Blount - C
Brookston - B

Cana - C
Caseyville - D
Catlin - B
Chalmers - C
Clermont - D
Cope - C
Corydon - C
Crosby - C

Dana - B
Della - C
Delmar - D
Donaldson - A

Elkins - D
Elston - B

Fairmount - D
Farmington - D
Fincastle - C

Galena - C
Ganesville - C
Genesse - B
Gibson - C

Hennepin - B
Homer - C
Hoytville - D
Huntington - B

Iona - B
Ionia - B

Jasper - B
Jennings - C

Kaskaskia - B
Kendallville - B
Keysport - C

Linkwood - B
Lorenzo - A
Lyles - B

Manlove - B
Martinsville - B
Maumee - D
Mellott - B
Metamora - B
Metea - B
Miami - B
Milton - C
Montgomery - D
Montmorenci - B
Morley - C
Muskingum - C
Mussey - B

Nappanee - D
Needham - C
Nineveh - B

Oaktown - A
Oakville - A
Ockley - B
Odell - C
Otterbein - C
Ottokee - A
Owensville - B

Parke - B
Parr - B
Pekin - C
Pewano - C
Philo - C
Pike - B
Plainfield - A
Pope - B
Princeton - B

Randolph - C
Reeseville - C

Rensselaer - C
Rodman - A
Romney - C
Ross - B
Russell - B
Russellville - C

Sciotoville - C
Seward - B
Shoals - C
Sidell - B
Sleeth - C
Sloan - D
Switzerland - B

Tawas - B
Thackery - B
Tilsit - C
Tippecanoe - B
Toronto - C

Uniontown - C

Vigo - D
Vincennes - C

Wabash - D
Wanatah - B
Warsaw - B
Washtenaw - C
Wea - B
Weiss - A
Wellston - B
Westland - D
Wheeling - B
Willette - B
Wingate - B

Xenia - B

Zanesville - C

(1) Furnished by the Soil Conservation Service.

TABLE 12

RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL-COVER COMPLEXES[1]

(Antecedent Moisture Condition II, and $I_a = 0.2S$)

Land Use	Cover Treatment or Practice	Hydrologic Condition	Hydrologic Soil Group A	B	C	D
Fallow	Straight Row	--	77	86	91	94
Row Crops	Straight Row	Poor	72	81	88	91
	Straight Row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured & Terraced	Poor	66	74	80	82
	Contoured & Terraced	Good	62	71	78	81
Small Grain	Straight Row	Poor	65	76	84	88
	Straight Row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured & Terraced	Poor	61	72	79	82
	Contoured & Terraced	Good	59	70	78	81
Close-Seeded Legumes[2] or Rotation Meadow	Straight Row	Poor	66	77	85	89
	Straight Row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured & Terraced	Poor	63	73	80	83
	Contoured & Terraced	Good	51	67	76	80
Pasture or Range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		--	59	74	82	86
Roads (Dirt)[3]		--	72	82	87	89
(Hard Surface)[3]		--	74	84	90	92

(1) Furnished by Soil Conservation Service.
(2) Close-Drilled or Broadcast.
(3) Including Right-of-Way.

TABLE 13

PEAK STAGES(2) - OHIO RIVER FLOODS OF RECORD

Station	Flood Stage (1)	Zero Gage (1)	Feb 1884	Mar 1907	Mar-Apr 1913	Mar-Apr 1936	Jan-Feb 1937	Mar 1945	Mar 1948
Pittsburgh	25	694.3	36.5	38.7	33.6	46.0	34.5	35.7	34.8
L&D 12 (Wheeling)	36	610.8	52.6	49.6	50.6	55.2	48.7	49.7	48.3
Parkersburg	36	562.0	53.9	51.6	58.9	48.0	55.4	51.8	53.2
Point Pleasant	40	514.1	59.9	54.8	62.8	54.4	62.7	56.0	58.1
L&D 28 (Huntington)	50	490.2	64.5	57.3	65.3	58.8	69.4	61.5	61.9
Portsmouth	50	470.8	66.3	60.8	67.9	59.2	74.2	65.9	65.1
Cincinnati	52	429.6	71.1	62.1	69.9	60.6	80.0	69.2	64.9
L&D 41 (Louisville)	55	374.0	74.0	63.6	72.6	63.6	85.4	74.4	68.1
Evansville	42	329.2	48.8	43.8	48.4	44.4	53.8	48.3	45.9
Paducah	39	286.3	54.2	42.3	54.3	49.1	60.6	50.5	45.4
Cairo	40	270.6	51.8	46.2	54.8	52.7	59.5	55.4	53.4

(1) Gage zero elevations, Ohio River datum, and flood stages are for 1963 gage locations.

(2) Maximum stage of record underscored.

TABLE 14

FLOOD CHARACTERISTICS OF STREAMS
IN THE OHIO RIVER BASIN

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Gage Zero (Ft)	Discharge Frequency - 1000 cfs: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified	Stage Frequency - Feet: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified
	ALLEGHENY RIVER BASIN														
1-2	Allegheny Riv, Red House, N Y	1,690	1,327.7	25.0		51.0		57.0		11.3		15.3		16.0	
1-5	French Cr, Cambridge, Pa	590	1,131.4	12.5		22.0		25		8.4		13.7		14.7	
1-6	French Cr, Meadville, Pa	1,017	798	14.3		26.0		29.9		58.3		63.9		64.7	
1-7	French Cr, Utica, Pa	1,029	1,019.5	14.8		29.5		32.5		10.5		14.2		15.0	
1-8	Allegheny Riv, Franklin, Pa	5,982	955.9	88.0	63.0	175.0	23.5	195.0	120.0	16.5	13.8	110.0	18.6	25.0	19.7
1-10	Allegheny Riv, Kittanning, Pa	8,973	771.3	136.0	110.0	268.0	193.0	300.0	213.0	21.9	20.3	29.0	25.4	30.6	26.6
1-12	Loyalhanna Cr, Latrobe, Pa	168.4	967.1	9.1		24.4		29.0		11.7		18.9		20.5	
1-14	Allegheny Riv, Natrona, Pa	11,410	736.7	175.0	120.0	344.0	179.0	385.0	192.0	22.8	18.8	33.2	22.9	35.4	23.8
1-16	Sandy Cr, Mouth (18)	57.3	56.0	1.4	0.77	5.0	1.9	5.9	2.2	56.0	54.0	59.8	56.7	60.4	57.1
	MONONGAHELA RIVER BASIN														
2-1	Buckhannon Riv, Buckhannon, W Va	215.4		7.2		11.9		12.9		1,411.6 (19)		1,416.5 (19)		1,417.4 (19)	
2-5	West Fork Riv, Weston, W Va	123	993.8	4.1		7.6		8.4		18.9		26.3		27.9	
2-7	West Fork Riv, Clarksburg, W Va	348	931.8	10.5		18.1		20.1		7.2		12.4		13.8	
2-9	Monongahela Riv, Lock 15 (2)	2,388	849.6	64.0	39.7	138.0	83.0	158.0	94.5	18.0	15.2	24.0	19.9	25.2	21.0
2-11	Cheat Riv, Rowlesburg, W Va (no regulation)	972	1,369.8	35.5		88		101		11.6		17.5		18.7	
2-14	Monongahela Riv, Lock 5 (2)			116	99	201	165	222	181						
2-15	Monongahela Riv, Lock 4 (2)	5,213	723.5	120	100	200	163	218	177	30.3	28.1	38.5	34.6	40.1	36.2
2-20	Big Piney Run, Salisbury, Pa (18)	24.5		1.1		5.5		6.8							
2-24	Youghiogheny Riv, Friendsville, Md	295	1,487.3												
	BEAVER RIVER BASIN														
3-2	Mahoning Riv, Warren, O (3)	599	855.6	11.4	5.8	24.2	10.4	28	11.8	14.7	9.6	20.9	13.9	22.0	14.9
3-3	Mahoning Riv, Youngstown, O (4)	899	826.53	14	8.7	30.3	16.8	35.5	19.5	14.97	11.47	24.07	19.37	26.27	21.17
3-6	Beaver Riv, Wampum, Pa (5)	2,235	736.2	27	20.9	56	43.3	64	49.5	16.6	14.2	26.0	22.0	28.0	23.8
3-7	Beaver Riv, Beaver Falls, Pa (5)	3,106	727.5	41	35.6	83	70.6	94	79.8	11.6	10.7	13.5	12.5	14.4	13.2
3-9	Mill Cr, Berlin Center, O (18)	19.0	1,032.9	0.95		2.75				5.67		7.7			
3-11	Lit Shenango Riv, Greenville, Pa (18)	104.0	46.0	2.9	2.0	8.5	5.3	10.0	6.1	43.4	42.6	47.7	45.3	48.7	45.9
3-12	Suger Run, Pymatuning Dam, Pa (18)	9.34		0.54		1.9		2.2							
	MUSKINGUM RIVER BASIN			(Observed)		(Observed)		(Observed)							
4-3	Walhonding Riv, Nellie, O	1,502		18.3		57.0		67.0							
4-8	Tuscarawas Riv, Newcomerstown, O	2,436		22.4		61.0		70.5							
4-9	Muskingum Riv, Coshocton, O	4,847		41.0		125.0		147.5							
4-10	Muskingum Riv, Dresden, O	5,982		46.0		120.0		137.0							
4-12	Muskingum Riv, Zanesville, O			52.5		149.0		172.0							
4-13	Muskingum Riv, McConnellsville, O	7,411		54.5		154.0		180.0							
4-16	Mill Cr, Coshocton, O (18)	27.2	782.0	1.1		3.02				9.1		10.81			
4-17	White-Eyes Cr Coshocton Exp Sta #196 (18)	0.473		0.100		0.828									
4-18	Lit Mill Cr, Coshocton Exp Sta #95 (18)	4.02		0.43		1.33									
4-19	Lit Mill Cr, Coshocton Exp Sta #97 (18)	7.16		0.71		2.12									
	LITTLE KANAWHA RIVER BASIN														
5-1	Lit Kanawha Riv, Glenville, W Va	386	697.8	11.8		20		22		27.1		32.5		33.5	

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Gage Zero (Ft)	Discharge Frequency - 1000 cfs: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified	Stage Frequency - Feet: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified
	LITTLE KANAWHA RIVER BASIN (Cont'd)														
5-2	Little Kanawha Riv, Grantsville, W Va	913	652.8	21.7		34.6		37.2		33.0		41.6		42.8	
5-3	Little Kanawha Riv, Creston, W Va			27.2		42		45		22.8		30.6		31.8	
5-4	Little Kanawha Riv, Palestine, W Va	1,515	585.5	52.8		55.4		61		29.4		40.1		42.2	
5-6	Saltlick Cr, Mouth (18)	49.5		1.73	1.2	5.45	4.22	6.35	5.0						
	HOCKING RIVER BASIN														
6-1	Hocking Riv, Enterprise, O	460	723.6	8.2		21.9		25.9		14.8		21.5		23.0	
6-2	Hocking Riv, Logan, O			7.5		18		20.8		20.3		23.1		23.6	
6-3	Hocking Riv, Nelsonville, O			7.95		19		22		76.6		80.1		80.6	
6-4	Hocking Riv, Chauncy, O			9.5		22.5		25.3		52.9		57.5		58.1	
6-5	Sunday Cr, Glouster, O	104	665.2	3.19		6.4		7.2		16.1		19.3		19.9	
6-6	Hocking Riv, Athens, O	944	615.6	14.8		32.6		37		19.0		23.2		23.9	
	KANAWHA RIVER BASIN			(Observed)		(Observed)		(Observed)							
7-2	New Riv, Ivanhoe, Va			19.5		84.0		104.0							
7-3	New Riv, Allisonia, Va			32.9		96.0		112.0							
7-4	New Riv, Radford, Va			34.0		109.0		128.0							
7-11	Greenbrier Riv, Hilldale, W Va			32.5		77.5		88.0							
7-16	Gauley Riv, above Belva, W Va	1,315	669.0	43.5		93.5		105		18.3		30.1		32.1	
7-21	Elk Riv, Queen Shoals, W Va														
7-22	Kanawha Riv, Charleston, W Va														
7-24	New Riv, Eggleston, Va			36.5		118.0		139.0							
7-25	New Riv, Hinton, W Va			97.0		210.0		240.0		11.1		17.2		18.7	
7-26	Elk Riv, Frametown, W Va														
7-27	Elk Riv, Clay, W Va														
7-28	New Riv, Caperton, W Va														
7-29	S Fk New Riv, Jefferson, N C	207	2,657.02	5.5		21.4		27.9							
7-30	Brush Cr, Mouth (18)	26.43		530	310	1.8	1.25	2.12	1.5						
	BIG SANDY RIVER BASIN														
8-1	Russell Fork, Haysi, Va	286	1,237.4	16.4		48.4		58.8		12.0		23.8		27.0	
8-2	Russell Fork, Elkhorn City, Ky			19.8		58		69.9		15.2		25.5		27.3	
8-3	Levisa Fork, Pikeville, Ky	1,237	633.2	32.2		87.5		102		32.5		53.1		56.4	
8-4	Levisa Fork, Prestonsburg, Ky			33.2		77.5		90		33.4		50.6		54.1	
8-5	Levisa Fork, Paintsville, Ky	2,143	566.8	41.7		92.9		108		36.5		50.5		53.2	
8-6	Tug Fork, Litwar, W Va	502	936.4	13.8		36.5		43.2		9.9		22.0		25.1	
8-8	Tug Fork, Kermit, W Va	1,185	581.8	27.8		71		84		33.8		45.9		48.2	
8-9	Big Sandy Riv, Louisa, Ky	3,870	512.8	53.8		140		164		43.1		55.3		55.7	
	LITTLE SANDY RIVER BASIN														
8-10	Little Sandy Riv, Grayson, Ky	398	557.9	11.9		29.4		34.6		22.5		28.9		30.2	
	TYGARTS CREEK BASIN														
8-11	Tygarts Cr, nr Greenup, Ky	241	547.1	7.7		20.7		24.2		17.6		22.7		23.3	
	GUYANDOTTE RIVER BASIN														
8-12	Guyandotte Riv, Man, W Va	762	710.9	22.2		52.2		60.2		16.1		25.7		28.0	

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Gage Zero (Ft)	Discharge Frequency - 1000 cfs: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified	Stage Frequency - Feet: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified
	GUYANDOTTE RIVER BASIN (Cont'd)														
8-13	Guyandotte Riv, Logan, W Va			22.3		51		57.7		16.6		32.0		34.6	
8-14	Guyandotte Riv, Branchland, W Va	1,226	547.9	24.2		52		59.8		30.8		47.9		51.3	
	TWELVEPOLE CREEK BASIN														
8-15	Twelvepole Cr, Wayne, W Va	291	576.5	8.25		21.6		25.4		21.1		30.9		32.4	
	SCIOTO RIVER BASIN														
9-2	Scioto Riv, nr Dublin, O	988	775.0	15.9		45		53		12.2		20.0		21.6	
9-4	Olentangy Riv, Stratford, O			9.45		25.6		30		6.4		10.4		11.4	
9-5	Scioto Riv, Columbus, O	1,624	680.4	27.5		74		86		9.9		18.7		20.7	
9-6	Alum Cr, Columbus, O	190	733.6	5.6		15.8		19		11.7		16.5		17.5	
9-7	Big Walnut Cr, Rees, O	544	698.2	15		37.4		43.38		15.8		20.1		20.7	
9-8	Big Darby Cr, Darbyville, O	533	713.6	11.5		36.3		42.65		12.1		16.7		17.4	
9-9	Scioto Riv, Circleville, O			44.5		146		176.16		19.1		25.9		27.1	
9-10	Deer Cr, Williamsport, O			9.85		34.5		41.27		13.4		17.2		17.7	
9-11	Scioto Riv, Chillicothe, O	3,847	594.0	53.2		156		187.64		21.7		33.2		35.4	
9-12	Paint Cr, nr Bourneville, O	808	665.2	23		62.5		72.78		16.2		20.9		21.6	
9-13	Scioto Riv, Higby, O	5,129	567.6	60.5		203		244.65		19.6		28.3		29.8	
9-14	Scioto Riv, Piketon, O			65.277		219		259.46		24.4		34.4		35.9	
9-16	Little Scioto Riv, Marion, O (18)	70.0	909.43	1.5		3.96				6.48		8.2			
	GREAT MIAMI RIVER BASIN														
10-2	Mad Riv, nr Springfield, O (8)	485	881.4	10	6.3	28.3	21.3	33.9	26.1	10.9	9.2	15.4	13.8	16.2	14.6
10-9	Great Miami Riv, Taylorsville Dam, O (17)	1,133	760	18.1	17.5	33.5	29.1	37.5	31.4	12.5	12.4	15.8	15.0	16.3	15.5
10-10	Great Miami Riv, Dayton, O (17)	2,513	723.7	44.3	33.5	102.9	60.1	112.9	64.2	13.9	8.6	21.6	13.0	22.3	13.6
10-12	Great Miami Riv, Hamilton, O (17)	3,639	564.6	58.2	48.9	134.3	98.1	149.9	110.3	15.9	9.5	23.5	16.1	24.7	17.4
10-19	Whitewater Riv, nr Alpine, Ind	539	750.2	17		65		81							
10-20	Whitewater Riv, Brookville, Ind (9)	1,239	595.7	34	31	126	90	155	117	18.1	17.2	33.7	28.8	36.7	32.5
	LITTLE MIAMI RIVER BASIN														
10-15	Little Miami Riv, Milford, O (6)	1,195	499.4	33.3	21.9	77	64	87.5	75	13.5	10.5	21.6	19.8	22.7	21.2
10-16	E Fk Little Miami Riv, Perintown, O	477	507.3	23		44		49		18.8		24.2		25.2	
	MILL CREEK BASIN														
10-21	Mill Cr, Reading, O (18)	73.1	527.0	3.0		7.8				14.4		23.3			
	KENTUCKY RIVER BASIN														
11-1	N Fk Kentucky Riv, Hazard, Ky	466	839.8	20.9		52.5		60.4		19.9	18.2	40.0	36.3	44.0	40.5
11-2	N Fk Kentucky Riv, Jackson, Ky	1,101	697.7	29.7		75		86.1		29.8	29.5	47.7	46.8	51.0	50.0
11-3	Mid Fk Kentucky Riv, Tallega, Ky	537	642.1	16		45		51.5		32.8	16.9	44.6	28.3	46.1	30.8
11-4	S Fk Kentucky Riv, Booneville, Ky	722	642.5	27.6		76.3		87.8		32.2		45.9		48.2	
11-5	Kentucky Riv, Lock 10, nr Winchester, Ky	3,955	557.4	61.5		108		117		25.3	21.3	43.0	39.4	47.1	43.7
11-8	Kentucky Riv, Lock 4, Frankfort, Ky (10)	5,412	462.1	70	63	128	123	142	138	29.9	26.9	48.4	46.3	52.4	50.4
11-9	Elkhorn Cr, nr Frankfort, Ky	473	540.2	13.2		36		42.3		11.6		16.1		16.7	
11-10	Kentucky Riv, Lock 2, Lockport, Ky	6,180	433.4	75		157		175		37.3	34.3	57.0	54.1	61.2	58.3

TABLE 14 (Cont'd)

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Gage Zero (Ft)	Discharge Frequency - 1000 cfs: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified	Stage Frequency - Feet: 2 Years Natural	2 Years Modified	50 Years Natural	50 Years Modified	100 Years Natural	100 Years Modified
	SALT RIVER BASIN														
11-11	Beech Fork, Bardstown, Ky	664	439.3	22		47		53.3							
11-12	Rolling Fork, nr Boston, Ky	1,290	400.4	30		65		74.5							
11-13	Salt Riv, Shepherdsville, Ky	1,230	406.6	31.5		64		71.2							
11-20	Plum Cr, Wilsonville, Ky (18)	19.1	1.4	2.8	2.0	3.6	2.55	3.75	2.6	5.35	4.6	6.1	5.1	6.2	5.2
	LICKING RIVER BASIN														
11-14	Licking Riv, Farmers, Ky (7)	826	646.6	13.4	7	27.3	7	30.9	7	23.7	18.0	27.6	18.0	28.3	18.0
11-17	S Fk Licking Riv, Cynthiana, Ky	615	688.5	19.7		58		69.9		18.4		27.8		29.6	
11-18	Licking Riv, Catawba, Ky (7)	3,250	498.4	50	45.5	101	91.1	112	101	33.0	30.9	54.7	50.5	58.9	54.8
	GREEN RIVER BASIN														
12-1	Green Riv, Greensburg, Ky	736	531.8	22.8		48.2		54.8		26.2	16.3	33.5	16.3	34.8	16.3
12-4	Green Riv, Lock 6, Brownsville, Ky	2,762	413.0	41.2		83.6		94		28.6	20.3	40.7	30.6	42.1	32.2
12-5	Barren Riv, Bowling Green, Ky	1,848	409.8	33.5		81		92							
12-7	Green Riv, Lock 4, Woodbury, Ky	5,403	389.6	67.5		128		143		45.4	37.4	52.6	47.9	53.7	49.1
12-8	Rough Riv, nr Dundee, Ky	757	393.2	11.7		32.2		37.3							
	WABASH RIVER BASIN														
13-1	Wabash Riv, Bluffton, Ind	506	793.0	7		17.4		20.2		13.5		18.9		19.7	
13-9	Wabash Riv, Wabash, Ind	1,733	642.7	23.8		58.7		67.6		20.4	17.1	25.3	22.5	26.3	23.5
13-10	Wabash Riv, Logansport, Ind	3,751	573.3	42.5		96.8		110.8		14.4	8.8	21.5	15.7	22.9	16.8
13-15	Wabash Riv, Lafayette, Ind	7,247	504.1	54		122		139		21.2	17.2	28.2	25.5	29.4	26.6
13-21	Vermilion Riv, nr Danville, Ill	1,280	503.33	15.6		52.5		65.5		19.4		28.8		30.2	
13-22	Wabash Riv, Montezuma, Ind	11,100	457.8	67		192		226		24.9		32.9		33.8	
13-23	Wabash Riv, Terre Haute, Ind	12,200	442.9	68		192		225		21.0	19.7	30.0	29.2	30.8	30.2
13-25	Wabash Riv, Vincennes, Ind	13,700	394.4	63		196		230		21.0	18.3	29.4	28.6	30.0	29.3
13-27	Embarrass Riv, Ste. Marie, Ill	1,540	446.8	17		67		88		19.8		30.2		32.4	
13-31	White Riv, Indianapolis, Ind	1,627	2.26	20.1		62		76.4		14.6		26.7		29.8	
13-33	White Riv, Spencer, Ind	2,980	526.0	33.5		89		106		21.0		26.6		27.6	
13-34	Eel Riv, Bowling Green, Ind	844	548.0	18.5		56		68		20.8		25.9		26.9	
13-37	E Fk White Riv, Seymour, Ind	2,333	550.7	37		123		154		17.8		20.4		20.8	
13-40	E Fk White Riv, Shoals, Ind (11)	4,954	442.2	42	37.5	116	109	135	128	25.3	23.6	38.9	37.8	40.5	39.5
13-41	White Riv, Petersburg, Ind (11)	11,139	400.0	80	72	239	223	283	267	23.7	23.3	29.6	29.2	30.6	30.3
13-42	Wabash Riv, Mt. Carmel, Ill (12)	28,600	371.3	147	132	395	374	458	441	23.4	22.7	29.5	29.0	31.2	30.6
13-44	Little Wabash Riv, below Clay City, Ill (at Wilcox)	1,130	392.3	16		60		75		22.2		27.9		28.9	
13-46	Little Wabash Riv, Carmi, Ill	3,090	339.9	14.5		54		64.5		29.1		37.8		39.7	
13-49	Youngs Cr, Edinburg, Ind (18)	109	670.2	3.5		13.8		16.5							
13-50	Vernon Fork, Butlerville, Ind (18)	87.3	669.4	6.6		25.7		31.0							

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	Gage Zero (Ft)	Discharge Frequency - 1000 cfs						Stage Frequency - Feet					
				2 Years		50 Years		100 Years		2 Years		50 Years		100 Years	
				Natural	Modified	Natural	Modified	Natural	Modified	Natural	Modified	Natural	Modified	Natural	Modified
	CUMBERLAND RIVER BASIN														
14-6	Wolf Cr Dam (tailwater) (13)		544.9	96	28	184	42	203	50	48.4	17.7	65.1	25.9	68.1	30.1
14-7	Cumberland Riv, nr Rowena, Ky (13)	5,790	540.7	96	28	184	42	203	50						
14-8	Cumberland Riv, Burkesville, Ky		521.8							46.7	23.7	60.7	33.2	63.2	35.9
14-10	Cumberland Riv, Celina, Tenn (14)	7,320	489.0	89	52	156	73	170	76	54.2	28.6	57.7	37.7	59.6	39.3
14-11	Cumberland Riv, Gainsboro, Tenn		474.1							41.4	25.9	55.9	34.9	58.2	37.6
14-12	Cumberland Riv, Granville, Tenn		451.3							46.9	33.3	61.5	42.0	63.6	45.5
14-15	Cumberland Riv, Carthage, Tenn (14)	10,700	437.7	129	83	229	109	250	120	44.5	30.9	62.3	39.1	65.5	42.5
14-16	Cumberland Riv, Lock & Dam 6, Tenn		414.7							51.4	41.5	67.8	47.6	70.8	49.9
14-17	Cumberland Riv, Lock & Dam 5, Tenn		402.7												
14-18	Cumberland Riv, Hunters Pt., Tenn		410.0							45.2	40.7	60.3	45.5	62.8	47.3
14-19	Cumberland Riv, Lock & Dam 3, Tenn	11,700	390.8												
14-22	Cumberland Riv, nr Nashville, Tenn (15)		368.1	126	92	201	114	216	120	44.3	35.8	56.5	41.6	57.8	42.9
14-24	Cumberland Riv, Lock & Dam A, Tenn		348.1												
14-26	Cumberland Riv, Clarksville, Tenn (15)		330.9	138	118	224	168	240	180	50.3	44.3	60.3	53.3	62.2	54.9
14-27	Cumberland Riv, Dover, Tenn (15)	16,530	323.8	141	126	220	188	243	208	42.0	39.3	51.6	47.2	53.2	48.7
14-28	Cumberland Riv, Lock & Dam F, Tenn		289.3							58.5	56.1	71.5	68.0	73.2	70.1
14-29	Cumberland Riv, Eureka, Ky		299.7							43.1	40.6	55.6	52.7	57.4	54.8
14-30	Cumberland Riv, Barkley Dam, Ky (headwater)		0.0							360.6		372.5		372.5	
14-30	Cumberland Riv, Barkley Dam, Ky (tailwater)		0.0												
14-31	Cumberland Riv, Smithland, Ky (16)	18,080	299.7	141.5	126	225	188	242	208	34.5	33.5	45.9	44.1	47.7	45.8
14-32	Cumberland Riv, Old Hickory Dam, Tenn (tailwater) (15)	11,700	0.0	120	86	201.5	116	218	129	427.5	418.6	440.8	425.1	443.2	427.3
14-33	Cumberland Riv, Cheatham Dam (headwater)	14,200	0.0							391.2	387.8	402.0	393.1	403.5	394.6
14-33	Cumberland Riv, Cheatham Dam (tailwater)	14,200	0.0							391.2	385.0	402.0	392.5	403.5	394.0
14-34	Cumberland Riv, Lock & Dam D, Tenn		323.8												
14-36	Roaring Riv, Hilham, Tenn (18)	78.7	770.0	3.9		10.2		12.0		7.8		12.2		12.8	
14-37	Falling Water Riv, Cookeville, Tenn (18)	73.3	894.5	3.9		8.5		9.6		20.6		27.4		28.5	
	OHIO RIVER MAIN STEM TRIBS														
15-6	Saline Riv, nr Junction, Ill	1,040	320.40	12.3		46.5		58.7		23.3		40.3		42.3	
15-8	Fourpole Cr, Mouth (18)	14.63		1.265	922	3.5	2.15	4.0	2.4						

FOOTNOTES:

(1) See Plate 16 for Station Locations.

(2) Modified by Tygart Reservoir.

(3) Modified by West Branch and Berlin Reservoirs (Modifications Upon Completion of West Branch Reservoir).

(4) Modified by West Branch, Mosquito Creek and Berlin Reservoirs (Modifications Upon Completion of West Branch Reservoir).

(5) Modified by West Branch, Mosquito Creek, Shenango and Berlin Reservoirs (Modifications Upon Completion of West Branch and Shenango Reservoirs).

FOOTNOTES (Cont'd):

(6) Modifications Upon Completion of Caesar Creek and East Fork Reservoirs.

(7) Modifications Upon Completion of Cave Run Reservoir.

(8) Modifications Upon Completion of Buck Creek Reservoir.

(9) Modifications Upon Completion of Brookville Reservoir.

(10) Modified by Buckhorn, Carr Fork and Red River Reservoirs (Modifications Upon Completion of Carr Fork and Red River Reservoirs).

(11) Modified by Cagles Mill and Monroe Reservoirs (Modifications Upon Completion of Monroe Reservoir).

(12) Modified by Mansfield, Huntington, Mississinewa and Salamonie Reservoirs (Modifications Upon Completion of Huntington, Mississinewa and Salamonie Reservoirs).

(13) Modified by Wolf Creek and Laurel Reservoirs (Modifications Upon Completion of Laurel Reservoir).

(14) Modified by Wolf Creek, Dale Hollow and Laurel Reservoirs (Modifications Upon Completion of Laurel Reservoir).

(15) Modified by Center Hill, Dale Hollow, Wolf Creek, J. Percy Priest and Laurel Reservoirs (Modifications Upon Completion of Laurel and J. Percy Priest Reservoirs).

(16) Modified by Center Hill, Dale Hollow, Wolf Creek, J. Percy Priest, Laurel and Barkley Reservoirs (Modifications Upon Completion of Laurel, Barkley and J. Percy Priest Reservoirs).

(17) Modified by Miami Conservancy District Retarding Basins.

(18) Data Furnished by Soil Conservation Service.

(19) No Gage Zero at This Location; Elevations are for Damage Point and Related to Frequency for Downstream Gage.

TABLE 15

LOW FLOW DISCHARGE FREQUENCY
AT SELECTED GAGING STATIONS - OHIO RIVER BASIN

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	7 Day - 10 Year Low Flow: Period of Record	7 Day - 10 Year Low Flow: (cfs)	7 Day - 10 Year Low Flow: (csm)	1 Day - 30 Year Low Flow: Period of Record	1 Day - 30 Year Low Flow: (cfs)	1 Day - 50 Year Low Flow: Period of Record	1 Day - 50 Year Low Flow: (cfs)
	ALLEGHENY RIVER BASIN								
1-1	Allegheny Riv, Eldred, Pa	550	1940-59	25	.0465		15		13.6
1-2	Allegheny Riv, Red House, N Y	1,690	1913-57	115	.0680				
1-3	Allegheny Riv, nr Kinzua, Pa	2,179	1904-55	172	.0789				
1-8	Allegheny Riv, Franklin, Pa (5)	5,982	1919-55	470	.0785	1931-58	301	1931-58	266.1
1-10	Allegheny Riv, Kittanning, Pa (6)	8,973	1904-55 (3)	750	.0835	1905-27; 1935-59	529	1905-27; 1935-59	478.6
1-13	Kiskiminetas Riv, Vandergrift, Pa	1,825	1938-59	219	.1204		112		99.8
1-14	Allegheny Riv, Natrona, Pa	11,410	1927-55	890	.0780		732		662.2
	MONONGAHELA RIVER BASIN								
2-2	Tygart Valley Riv, Belington, W Va	408	1908-60	4.2	.0102		1.4		1.1
2-3	Tygart Valley Riv, Philippi, W Va	916	1940-60	8	.0087	1940-60	2.7	1940-60	2
2-4	Tygart Valley Riv, Colfax, W Va	1,366	1940-59	192	.1407		125		114
2-6	West Fork Riv, Butcherville, W Va	181	1916-24; 1926-60	0.2	.0011				
2-7	West Fork Riv, Clarksburg, W Va (2)	384	1923-59	2.3	.0059				
2-8	West Fork Riv, Enterprise, W Va	759	1908-15; 1933-60	11	.0146		4.9		4
2-9	Monongahela Riv, Lock 15, Hoult, W Va	2,388	1916-25; 1939-60	99	.0414		46		37.6
2-10	Cheat Riv, nr Parsons, W Va	718	1913-60	33	.0459		17		14.2
2-13	Monongahela Riv, Greenboro, Pa	4,407	1939-59	384	.0872		208		187.1
2-17	Youghiogheny Riv, Connellsville, Pa (4)	1,326	1908-59	75	.0565	1908-59	27	1908-59	21
2-18	Tygart Valley Riv, Grafton, W Va (3)	1,184	1938-59	170	.1144				
2-24	Youghiogheny Riv, Friendsville, Md	295	1941-60	54.5	.1848	1941-60			
	BEAVER RIVER BASIN								
3-1	W Br Mahoning Riv, nr Newton Falls, Ohio	97.8	1926-46	4.1	.0419		2.8		2.5
	MUSKINGUM RIVER BASIN								
4-1	Jerome Fork, Jeromeville, Ohio	120	1925-46	2.4	.0200		1.8		1.7
4-4	Tuscarawas Riv, Clinton, Ohio	165	1926-46	18	.1090		10		9.1
4-5	Nimishillen Cr, North Industry, Ohio	175	1921-46	23	.1314		10		8.3
4-6	Sandy Cr, Sandyville, Ohio	481	1923-46	61	.1268		38		33.2
4-9	Muskingum Riv, Coshocton, Ohio (7)	4,842	1936-61	464	.0958	1936-61	337	1936-61	363
4-10	Muskingum Riv, Dresden, Ohio (8)	5,982	1922-61	498	.0832	1922-61	375	1922-61	345
4-11	Licking Riv, Toboso, Ohio	672	1921-46	50	.0744		40		38.3
4-12	Muskingum Riv, Zanesville, Ohio (7)	6,840	1940-54	550	.0804	1940-54	400	1940-54	370
4-13	Muskingum Riv, McConnellsville, Ohio (8)	7,411	1922-61	565	.0762	1922-61	397	1922-61	362
	LITTLE KANAWHA RIVER BASIN								
5-4	Little Kanawha Riv, Palestine, W Va	1,515	1943-60	36	.0237		8.7		5.7
	HOCKING RIVER BASIN								
6-6	Hocking Riv, Athens, Ohio	944	1915-46	36	.0381		11.5		8.3
	KANAWHA RIVER BASIN								
7-1	New Riv, Galax, Va	1,131	1930-61	359	.3174		259		234
7-2	New Riv, Ivanhoe, Va	1,340	1930-61	398	.2970		232		208
7-3	New Riv, Allisonia, Va	2,202	1913-57	634	.2879				
7-4	New Riv, Radford, Va (9)	2,748	1907-61	845	.3074	1907-61	565	1907-61	520
7-5	Walker Cr, Bane, Va	305	1929-61	29	.0950		21		19
7-6	Wolf Cr, nr Narrows, Va	223	1930-61	17	.0762		11		10

TABLE 15 (Cont'd)

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	7 Day - 10 Year Low Flow: Period of Record	7 Day - 10 Year Low Flow: (cfs)	7 Day - 10 Year Low Flow: (csm)	1 Day - 30 Year Low Flow: Period of Record	1 Day - 30 Year Low Flow: (cfs)	1 Day - 50 Year Low Flow: Period of Record	1 Day - 50 Year Low Flow: (cfs)
	KANAWHA RIVER BASIN (Cont'd)								
7-7	East Riv, Mouth	76	1930-61	4.5			3.6		2.6
7-8	New Riv, Glenlyn, Va	3,768	1927-61	1,050	.2786		735		675
7-9	Greenbrier Riv, Buckeye, W Va	540	1930-60	11	.0203		6		4.8
7-10	Greenbrier Riv, Alderson, W Va	1,357	1924-55	42	.0309	1924-55	30	1924-55	26
7-11	Greenbrier Riv, Hilldale, W Va	1,625	1895-1960	56	.0344		34		29
7-12	Greenbrier Riv, Mouth	1,647	1895-1960	56	.0340	1895-1960	34	1895-1960	29
7-15	Gauley Riv, nr Summersville, W Va	680	1929-60	5.5	.0080		1.6		1
7-16	Gauley Riv, above Belva, W Va	1,315	1929-60	12	.0091		4.8		3.4
7-19	Elk Riv, Centralia, W Va	281	1930-60	3.7	.0131		1.2		0.88
7-20	Elk Riv, Sutton, W Va	543	1939-60	4	.0073		1.2		0.82
7-21	Elk Riv, Queen Shoals, W Va	1,145	1929-60	6.2	.0054		1.9		1.3
7-22	Kanawha Riv, Charleston, W Va	10,419	1940-60	1,200	.1151		880		780
7-29	S Fk New Riv, nr Jefferson, N C	207	1924-59	89	.4300	1924-59	59	1924-59	54
	GUYANDOTTE RIVER BASIN								
8-14	Guyandotte Riv, Branchland, W Va	1,226	1929-60	20	.0163		10.3		8.7
	BIG SANDY RIVER BASIN								
8-3	Levisa Fork, Pikeville, Ky (10)	1,237	1938-58	3.9	.0031	1926-60	1.4	1926-60	1
8-5	Levisa Fork, Paintsville, Ky (11)	2,143	1929-60	15	.0023	1929-60	7	1929-60	5.4
8-6	Tug Fork, Litwar, W Va	502	1930-61	21	.0418		13.8		12
8-8	Tug Fork, nr Kermit, W Va	1,185	1929-61	26	.0219		15.4		13
8-9	Big Sandy Riv, Louisa, Ky (12)	3,870	1929-60	59	.0152	1929-60	29	1929-60	22
	LITTLE SANDY RIVER BASIN								
8-10	Little Sandy Riv, Grayson, Ky (13)	402	1938-60	2.7	.0067	1929-60	0.7	1929-60	0.5
	SCIOTO RIVER BASIN								
9-5	Scioto Riv, Columbus, Ohio (14)	1,624	1920-58	41	.0252	1921-55	19	1921-55	14
9-9	Scioto Riv, Circleville, Ohio (14)	3,217		128	.0397	1921-55	54	1921-55	43
9-11	Scioto Riv, Chillicothe, Ohio (14)	3,847	1920-59	147	.0382	1921-55	71	1921-55	53
9-15	Scioto Riv, Mouth	6,510		390	.0599	1921-55	137	1921-55	113
	GREAT MIAMI RIVER BASIN								
10-1	Mad Riv, Urbana, Ohio	157	1927-31; 1941-60	33	.2101				
10-3	Mad Riv, Springfield, Ohio	485	1914-59	115	.2371	1914-59	89	1914-59	83
10-5	Great Miami Riv, Sidney, Ohio (17)	545	1914-59	18	.0330	1921-45	7.7	1921-45	6.6
10-6	Loramie Cr, Lockington, Ohio	261	1921-45	3.2	.0122		2.2		2
10-8	Stillwater Riv, Englewood, Ohio	646	1921-45	12	.0185		4.1		3.2
10-9	Great Miami Riv, Taylorsville, Ohio	1,155	1922-59	46	.0398		30		26
10-10	Great Miami Riv, Dayton, Ohio(15 & 17)	2,513	1913-59	175	.0696				
10-11	Great Miami Riv, Miamisburg, Ohio (17)	2,718	1916-20; 1924-35; 1952-59	223	.0820				
10-12	Great Miami Riv, Hamilton, Ohio (16 & 17)	3,639	1910-18; 1927-59	281	.0772	1931-58	161	1931-58	143
10-17	E Fk Whitewater Riv, Richmond, Ind	123	1949-59	2	.0162				
10-18	E Fk Whitewater Riv, nr Brookville, Ind	382	1954-58	19	.0497				
10-19	Whitewater Riv, Alpine, Ind	539	1924-58	45	.0834				
10-20	Whitewater Riv, Brookville, Ind	1,239	1924-55	82	.0661				

TABLE 15 (Cont'd)

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	7 Day - 10 Year Low Flow Period of Record	7 Day - 10 Year Low Flow (cfs)	7 Day - 10 Year Low Flow (csm)	1 Day - 30 Year Low Flow Period of Record	1 Day - 30 Year Low Flow (cfs)	1 Day - 50 Year Low Flow Period of Record	1 Day - 50 Year Low Flow (cfs)
	LITTLE MIAMI RIVER BASIN								
10-16	E Fk Little Miami Riv, Perintown, Ohio	477	1925-46	0.7	.0014		0.4		0.3
	KENTUCKY RIVER BASIN								
11-1	N Fk Kentucky Riv, Hazard, Ky	466	1940-60	1.5	.0032	1940-60	0.4	1940-60	0.3
11-2	N Fk Kentucky Riv, Jackson, Ky	1,101	1920-30; 1938-60	2.2	.0019				
11-5	Kentucky Riv, Lock 10, nr Winchester, Ky	3,955	1908-58	33	.0083				
11-6	Kentucky Riv, nr Richmond, Ky (18)	3,953				1910-60	19	1910-60	15
11-7	Dix Riv, nr Danville, Ky	318	1943-60						
11-8	Kentucky Riv, Frankfort, Ky (19)	5,412	1926-60	112	.0206	1926-60	35	1926-60	27
11-10	Kentucky Riv, Lock 2, Lockport, Ky	6,180	1926-29; 1933-36	163	.0263				
	SALT RIVER BASIN								
11-11	Beech Fork, Bardstown, Ky	669	1940-58	0.04	.0001				
11-12	Rolling Fork, nr Boston, Ky	1,299	1939-60	1.3	.0010	1939-60	0.3	1939-60	0.2
	LICKING RIVER BASIN								
11-14	Licking Riv, Farmers, Ky	831	1938-60	3.1	.0037				
11-16	Licking Riv, Falmouth, Ky	2,367				1925-26; 1939-60	3.5		
11-17	S Fk Licking Riv, Cynthiana, Ky	621	1938-60	0.7	.0011				
11-18	Licking Riv, Catawba, Ky	3,300	1929-58	10.3	.0030				
	GREEN RIVER BASIN								
12-1	Green Riv, Greensburg, Ky (20)	736	1940-60	1.7	.0023	1940-60	0.5	1940-60	0.3
12-2	Nolin Riv, Wax, Ky	600	1937-60	44	.0733				
12-3	Green Riv, d/s Mouth of Nolin Riv	2,758	1925-30; 1939-50	141	.0511				
12-4	Green Riv, Lock 6, Brownsville, Ky	2,762	1925-30; 1939-58	141	.0510				
12-5	Barren Riv, Bowling Green, Ky (22)	1,848	1939-60	53	.0286	1939-60	32	1939-60	27
12-6	Green Riv, d/s Mouth of Barren Riv	5,400	1938-60	234	.0433				
12-7	Green Riv, Lock 4, Woodbury, Ky	5,403	1938-60	241	.0446				
12-9	Green Riv, Lock 2, Calhoun, Ky (2) (formerly Green Riv at Livermore, Ky)	7,564	1930-58	306	.0404	1930-60	211	1930-60	18
	WABASH RIVER BASIN								
13-1	Wabash Riv, Bluffton, Ind	506	1938-58	4.7	.0082	1931-59	3	1931-59	2.6
13-2	Wabash Riv, Huntington, Ind	710	1940-58	9	.0126				
13-3	Little Wabash Riv, nr Huntington, Ind (formerly Little Riv, nr Huntington, Ind)	266	1944-58	2.3	.0086				
13-4	Mississinewa Riv, nr Ridgeville, Ind	130	1947-58	0.8	.0061				
13-5	Mississinewa Riv, nr Eaton, Ind	304	1952-58	2.4	.0078				
13-6	Mississinewa Riv, Marion, Ind	677	1924-58	16	.0236				
13-7	Mississinewa Riv, Peoria, Ind	809	1953-58	33	.0407				
13-8	Wabash Riv, Peru, Ind	2,655	1944-58	87	.0327				
13-9	Wabash Riv, Wabash, Ind	1,733	1924-58	26	.0150	1930-59	15	1930-59	13
13-10	Wabash Riv, Logansport, Ind	3,751	1924-58	190	.0506	1928-59	128	1928-59	116

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OHIO RIVER BASIN COMPREHENSIVE SURVEY. VOLUME IV. APPENDIX C. H--ETC(U)

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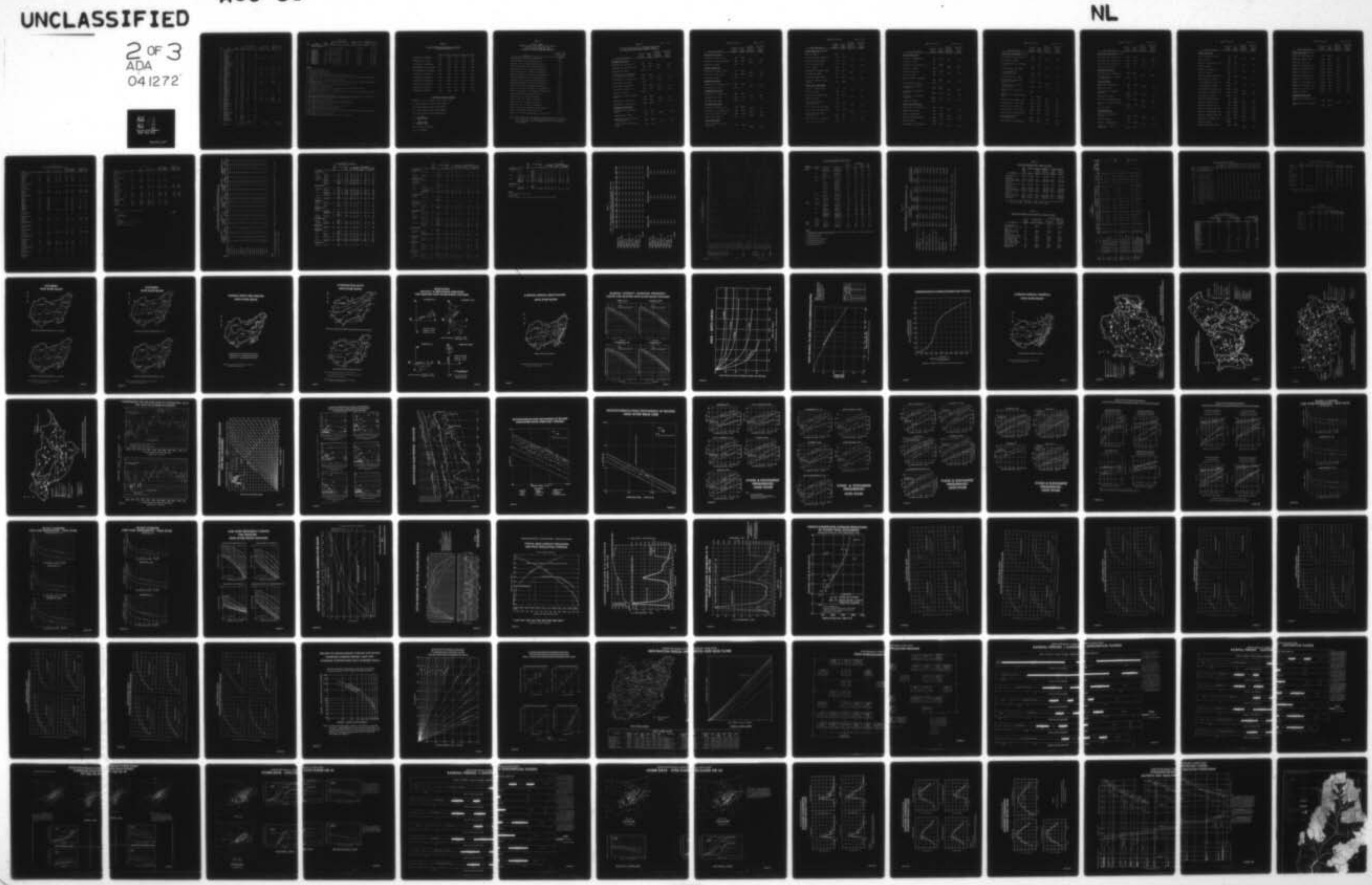

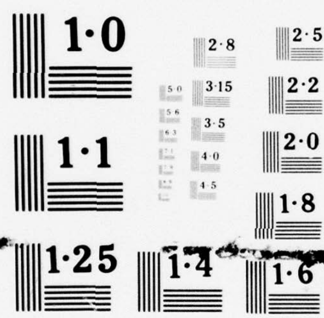
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TABLE 15 (Cont'd)

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	7 Day - 10 Year Low Flow: Period of Record	7 Day - 10 Year Low Flow (cfs)	7 Day - 10 Year Low Flow (csm)	1 Day - 30 Year Low Flow: Period of Record	1 Day - 30 Year Low Flow (cfs)	1 Day - 50 Year Low Flow: Period of Record	1 Day - 50 Year Low Flow (cfs)
	WABASH RIVER BASIN (Cont'd)								
13-12	Wildcat Cr, Greentown, Ind	162	1945-58	1.2	.0074				
13-13	Wildcat Cr, Owasco, Ind	390	1944-58	15	.0384				
13-14	S Fk Wildcat Cr, nr Lafayette, Ind	246	1944-58	18	.0731				
13-15	Wabash Riv, Lafayette, Ind	7,247	1924-58	535	.0738	1928-59	392	1928-59	361
13-16	Wabash Riv, Covington, Ind	8,208	1940-58	630	.0767				
13-17	W Br Salt Fork, Urbana, Ill	71.4	1937-55	2.3	.0322				
13-18	Salt Fork, Vermilion Riv, nr Homer, Ill	344	1945-55	6.8	.0197				
13-19	Salt Fork, Vermilion Riv, nr Catlin, Ill	959	1940-55	12	.0125				
13-20	Salt Fork, Vermilion Riv, nr Danville, Ill	1,280	1915-20; 1929-55	14	.0109				
13-22	Wabash Riv, Montezuma, Ind	11,100	1928-58	775	.0698	1928-59	578	1928-59	527
13-23	Wabash Riv, Terre Haute, Ind	12,200	1928-58	900	.0737	1928-59	654	1928-59	597
13-24	Wabash Riv, Riverton, Ind	13,100	1939-58	1,040	.0793				
13-25	Wabash Riv, Vincennes, Ind	13,700	1930-58	1,060	.0773	1930-59	849	1930-59	776
13-26	N Fk Embarrass Riv, nr Oblong, Ill	319	1916-56	0.1	.0003				
13-27	Embarrass Riv, St. Marie, Ill	1,513	1915-58	16	.0105	1915-58	6.1	1915-58	5
13-28	White Riv, Muncie, Ind	242	1931-58	1.6	.0066				
13-29	White Riv, Anderson, Ind	401	1947-58	36	.0897				
13-30	White Riv, Nobelsville, Ind	837	1928-59	58	.0692	1928-59	40	1928-59	36
13-31	White Riv, Indianapolis, Ind	1,627	1930-58	105	.0645	1930-58	79	1930-58	75
13-32	White Riv, Martinsville, Ind	2,435	1939-58	125	.0513				
13-33	White Riv, Spencer, Ind	2,980	1926-58	210	.0704		152		138
13-34	Eel Riv, Bowling Green, Ind	844	1931-58	17	.0200				
13-35	White Riv, Newberry, Ind	4,696	1929-59	291	.0619		213		193
13-36	E Fk White Riv, Columbus, Ind	1,692	1940-58	103	.0449		71		63
13-37	E Fk White Riv, Seymour, Ind	2,333	1928-58	155	.0664	1928-59	107	1928-59	96
13-38	E Fk White Riv, nr Bedford, Ind	3,870	1940-58	182	.0470				
13-39	Salt Cr, Peerless, Ind	582	1939-49; 1957-58	0.9	.0015				
13-40	E Fk White Riv, Shoals, Ind	4,954	1924-58	222	.0448	1928-59	99	1928-59	86
13-41	White Riv, Petersburg, Ind	11,139	1928-58	685	.0614	1929-59	474	1929-59	423
13-42	Wabash Riv, Mt. Carmel, Ill	28,600	1928-59	2,250	.0787	1928-58	1,641	1928-58	1,503
13-43	Bonpas Cr, Browns, Ill	235	1941-55						
13-44	Little Wabash Riv, below Clay City, Ill	1,130	1916-56	0.55	.0004				
13-45	Skillet Fork, Wayne City, Ill	475	1916-56						
13-46	Little Wabash Riv, Carmi, Ill	3,090	1940-58	5.2	.0016				
13-47	Sugar Cr, Crawfordsville, Ind	509	1939-58	5	.0098				
13-48	Wabash Riv, Delphi, Ind	4,032	1940-58	204	.0505				
	CUMBERLAND RIVER BASIN								
14-1	Cumberland Riv, Barbourville, Ky	960	1923-30; 1948-60	8.3	.0086				
14-2	Cumberland Riv, Williamsburg, Ky	1,607	1951-60	8.6	.0053				
14-3	Cumberland Riv, Cumberland Falls, Ky	1,977	1908-10; 1915-30; 1933-60	16	.0080				
14-20	W Fk Stones Riv, nr Murfreesboro, Tenn	128	1932-61	0.3	.0023				
			Nat / Reg	Nat / Reg (23)			Nat / Reg (23)		Nat / Reg (23)
14-7	Cumberland Riv, Rowena, Ky	5,790	1940-49 / 1957-63	96 / 325	.0562		55 / 38.5		41.5 / 32.5

TABLE 15 (Cont'd)

Map No. (1)	Stream & Station	Drainage Area (Sq Mi)	7 Day - 10 Year Low Flow: Period of Record		(cfs)		(csm)	1 Day - 30 Year Low Flow: Period of Record	(cfs)		1 Day - 50 Year Low Flow: Period of Record	(cfs)	
	CUMBERLAND RIVER BASIN (Cont'd)												
			Nat	Reg	Nat	Reg (23)			Nat	Reg (23)		Nat	Reg (23)
14-10	Cumberland Riv, Celina, Tenn	7,307	1923-42	1957-63	190	840	.1150		120	218		97	182
14-15	Cumberland Riv, Carthage, Tenn	10,690	1923-42	1957-63	520	3,125	.2850		340	1,880		290	1,760
14-22	Cumberland Riv, Nashville, Tenn	12,841	1893-1942	1957-63	565	3,500	.2625		345	2,375		285	2,225
14-26	Cumberland Riv, Clarksville, Tenn	15,897	1925-42		645	3,800	.2390		390	2,650		320	2,500
14-27	Cumberland Riv, Dover, Tenn	16,417	1938-42	1957-63	710	3,850	.2345		450	2,675		380	2,525
14-31	Cumberland Riv, Smithland, Tenn	17,913	1940-42	1957-63	810	4,100	.2290		545	2,950		475	2,800
14-32	Cumberland Riv, Old Hickory, Tenn	11,674	1932-41	1957-63	475	3,450	.2950		280	2,280		225	2,150
14-33	Cumberland Riv, Cheatham, Tenn	14,160		1957-63	610	3,650	.2580		375	2,500		305	2,375

FOOTNOTES:

(1) See Plate 11 for Station Locations.

(2) Diversion for City of Clarksburg Water Supply.

(3) Low Flow Regulated by Tygart Reservoir since 1938.

(4) Low Flow Regulated by Deep Creek Reservoir since 1925 and by Youghiogheny Reservoir since 1943.

(5) Low Flow Regulation by Tionesta Creek Reservoir since 1940 and Lake Chantangua Reservoir and by Allegheny Reservoir Under Construction 1963 on Allegheny.

(6) Actual Period 1904-28; 1935-55. Period from 1929-34 Estimated from Franklin.

(7) Low Flow Regulated by Bolivar, Leesville, Atwood, Dover, Beech City, Piedmont, Clendening, Tappan, Charles Mill, Pleasant Hill, Mohicanville, and Mohawk Reservoirs since 1936.

(8) Low Flow Regulated by Reservoirs Listed in (7) Plus Senecaville and Wills Creek since 1938.

(9) Low Flow Regulated by Clayton Reservoir since 1939.

(10) Low Flow Regulated by J. W. Flannagan Reservoir since 1963 and Fishtrap and North Fork Reservoirs Under Construction 1963.

(11) Low Flow Regulated by Dewey Reservoir since 1950 and Those Listed in (10).

(12) Low Flow Regulated by Dewey Reservoir since 1950, J. W. Flannagan Reservoir since 1963, and Fishtrap and North Fork Reservoirs Under Construction 1963.

(13) Flow Regulated by Grayson Reservoir Under Construction 1964.

(14) Flow on Scioto Above Columbus Regulated by Griggs Reservoir and O'Shaughnessy Reservoir since 1921 and 1924, Respectively. Olentangy River by Delaware Reservoir since 1951. Diversion from Big Walnut Creek to Scioto from Hoover Reservoir since 1955.

(15) Some Diversion above Dayton for Municipal Water Supply.

(16) Low Flow Regulated by Power Plant at Hamilton and Also Small Diversion for Municipal Water Supply.

(17) Miami Conservancy District Reservoirs Have Uncontrolled Outlets and Have No Low Flow Regulation.

(18) Low Flow Regulated by Buckhorn Reservoir since 1960.

(19) Low Flow Regulated by Herrington Lake since 1925 and Reservoir Listed in (18).

(20) Low Flow Regulated by Green River Reservoir Under Construction 1964.

(21) Low Flow Regulated by Nolin Reservoir since 1962, by Barren Reservoir since 1963, by Rough River Reservoir since 1959, Plus Reservoir Listed in (20).

(22) Low Flow Regulated by Barren River Reservoir since 1963.

(23) Low Flow Regulated by Wolf Creek, Dale Hollow, Center Hill, Old Hickory, and Cheatam Reservoirs.

TABLE 16

LOW FLOW ROUTING COEFFICIENTS - OHIO RIVER
(Muskingum Equation)

	t	K	X	C_1	C_2
Daschields to Wheeling	0.25	.500	.10	.435	.130
Wheeling to St. Marys	0.25	.600	.25	.435	-.043
St. Marys to Parkersburg	0.25	.200	.25	.909	.273
Parkersburg to Pt. Pleasant	0.25	.550	.30	.490	-.078
Pt. Pleasant to Huntington	0.25	.500	.35	.556	-.111
Huntington to Maysville	0.25	.800	.25	.345	-.103
Maysville to Cincinnati	0.25	.500	.30	.526	-.053
Cincinnati to Louisville	0.50	1.000	.30	.526	-.053
Louisville to Evansville	0.50	1.250	.35	.471	-.176
Evansville to Golconda	0.50	1.000	.25	.500	.000
Golconda to Metropolis	0.50	.450	.25	.851	.234

COEFFICIENT METHOD OF ROUTING

Equation: $0_2 = 0_1 + [C_0(I_1 - 0_1) + C_1(I_2 - I_1)]$

0_1 = Reach outflow at start of time period.

0_2 = Reach outflow at end of time period.

I_1 = Reach inflow at start of time period.

I_2 = Reach inflow at end of time period.

$$C_0 = \frac{2\,\Delta t}{2K(1-X) + \Delta t}$$

$$C_1 = \frac{\Delta t - 2KX}{2K(1-X) + \Delta t}$$

Δt = Time period in days.

K & X = Constants.

TABLE 17

TIME OF TRAVEL
BETWEEN SELECTED OHIO RIVER MAIN STEM POINTS
FOR A 30-DAY AVERAGE LOW FLOW
HAVING A TEN-YEAR RECURRENCE INTERVAL

Points	Travel Time Between Points in Days
Pittsburgh, Pa, to Mouth of Beaver Riv	6.8
Mouth of Beaver Riv to Wheeling, W Va	15.6
Wheeling, W Va, to Mouth of Muskingum Riv	9.1
Mouth of Muskingum Riv to Parkersburg, W Va	2.9
Parkersburg, W Va, to Mouth of Hocking Riv	3.3
Mouth of Hocking Riv to Mouth of Kanawha Riv	11.3
Mouth of Kanawha Riv to Mouth of Guyandotte Riv	7.7
Mouth of Guyandotte Riv to Huntington, W Va	1.4
Huntington, W Va, to Mouth of Big Sandy Riv	1.0
Mouth of Big Sandy Riv to Mouth of Scioto Riv	7.9
Mouth of Scioto Riv to Mouth of Licking Riv	23.1
Mouth of Licking Riv to Mouth of Great Miami Riv	4.3
Mouth of Great Miami Riv to Mouth of Kentucky Riv	10.3
Mouth of Kentucky Riv to Louisville, Ky	7.4
Louisville, Ky, to Mouth of Salt Riv	4.3
Mouth of Salt Riv to Mouth of Green Riv	24.2
Mouth of Green Riv to Evansville, Ind	0.5
Evansville, Ind, to Mouth of Wabash Riv	4.2
Mouth of Wabash Riv to Mouth of Cumberland Riv	4.4
Mouth of Cumberland Riv to Paducah, Ky	0.6
Paducah, Ky, Mouth of Tennessee Riv, to Cairo, Ill	2.7

NOTE: Data assumes Corps of Engineers Reservoirs completed, under construction, or in preconstruction planning as of 1 July 1963 are in operation, and all contemplated main stem navigation dams completed.

TABLE 18

SEVEN-DAY TEN-YEAR LOW FLOW DISCHARGE TRAVEL TIMES BETWEEN OHIO RIVER BASIN TRIBUTARY STATIONS

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
ALLEGHENY RIVER BASIN				
Conemaugh Riv, Johnstown, Pa	656	52.5		
			32.5	2.3
Conemaugh Riv, Blairsville, Pa	869	20.1		
			20.1	1.4
Conemaugh Riv, Mouth	1,370	0		
Kiskiminetas Riv, Confluence of Conemaugh & Loyalhanna	1,669	26.8		
			15.5	2.1
Kiskiminetas Riv, Apollo, Pa	1,825	11.3		
			11.3	1.4
Kiskiminetas Riv, Mouth	1,887	0		
Clarion Riv, Ridgeway, Pa	307	90.1		
			64.9	9.2
Clarion Riv, Clarion, Pa	966	25.2		
			25.2	5.1
Clarion Riv, Mouth	1,249	0		
Allegheny Riv, Port Allegheny, N Y	248	288.3		
			35.0	5.2
Allegheny Riv, Olean, N Y	1,168	253.3		
			21.0	2.7
Allegheny Riv, Salmanca, N Y	1,609	232.3		
MONONGAHELA RIVER BASIN				
Buckhannon Riv, Buckhannon, W Va	227	19.0		
			19.0	5.5
Buckhannon Riv, Mouth	308	0		
Tygart Valley Riv, d/s Mouth of Buckhannon Riv	904	49.8		
			5.0	1.5
Tygart Valley Riv, Philippi, W Va	916	44.8		

TABLE 18 (Cont'd)

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
MUSKINGUM RIVER BASIN				
Killbuck Cr, Wooster, Ohio	196	48.0		
			20.0	6.6
Killbuck Cr, Millersburg, Ohio	396	28.0		
			28.0	8.5
Killbuck Cr, Mouth	613	0		
HOCKING RIVER BASIN				
Hocking Riv, Lancaster, Ohio	50	88.0		
			20.0	3.0
Hocking Riv, Logan, Ohio	502	68.0		
			68.0	6.3
Hocking Riv, Mouth	1,185	0		
KANAWHA RIVER BASIN				
Greenbrier Riv, Alderson, W Va	1,487	26.7		
			26.7	14.8
Greenbrier Riv, Mouth	1,647	0		
GUYANDOTTE RIVER BASIN				
Guyandotte Riv, Logan, W Va	859	79.6		
			72.4	26.0
Guyandotte Riv, Mud Cr	1,309	7.2		
			7.2	1.7
Guyandotte Riv, Mouth	1,682	0		
BIG SANDY RIVER BASIN				
Tug Fork Riv, Litwar, W Va	502	106.2		
			48.8	9.2
Tug Fork Riv, Williamson, W Va	938	57.4		
			22.4	4.4
Tug Fork Riv, Kermit, W Va	1,185	35.0		
			35.0	6.8
Tug Fork Riv, Mouth	1,555	0		
SCIOTO RIVER BASIN				
Paint Cr, Washington Court House, Ohio	121	67.4		
			67.4	10.0

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
SCIOTO RIVER BASIN (Cont'd)				
Paint Cr, Mouth	1,143	0		
Little Scioto Riv, Marion, O	72	7.0	7.0	1.5
Little Scioto Riv, Mouth	110	0		
Salt Cr, Jackson, Ohio	77	15.0	15.0	2.9
Salt Cr, Mouth	503	0		
Olentangy Riv, Delaware, Ohio	387	28.1	28.1	4.7
Olentangy Riv, Mouth	523	0		
Scioto Riv, Kenton, Ohio	145	205.0	25.0	4.6
Scioto Riv, Mouth of Little Scioto	410	180.0		
LITTLE MIAMI RIVER BASIN				
Turtle Cr, Lebanon, Ohio	15	7.2	7.2	0.7
Turtle Cr, Mouth	65	0		
Todd Fork, Wilmington, Ohio	23	25.2	25.2	2.5
Todd Fork, Mouth	261	0		
E Fk Little Miami Riv, Williamsburg, O	238	35.2	35.2	6.3
E Fk Little Miami Riv, Mouth	501	0		
Little Miami Riv, Xenia, Ohio	129	74.6	42.9	3.7
Little Miami Riv, South Lebanon, Ohio	620	31.7	7.4	0.6
Little Miami Riv, Loveland, O	760	24.3	24.3	2.0
Little Miami Riv, Mouth	1,755	0		

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
LICKING RIVER BASIN				
Triplett Cr, Morehead, Ky	48	13.2		
			13.2	3.5
Triplett Cr, Mouth	187	0		
Hinkston Cr, Mt. Sterling, Ky	7	66.8		
			66.8	18.5
Hinkston Cr, Mouth	260	0		
Stoner Cr, Paris, Ky	239	14.0		
			14.0	3.3
Stoner Cr, Mouth	284	0		
S Fk Licking Riv, Cynthiana, Ky	621	49.1		
			49.1	8.1
S Fk Licking Riv, Mouth	927	0		
Licking Riv, d/s Mouth of Triplett Cr	1,019	168.5		
			97.1	22.6
Licking Riv, u/s Mouth of North Fk	1,993	71.4		
			19.7	3.7
Licking Riv, u/s Mouth of South Fk	2,367	51.7		
			51.7	13.2
Licking Riv, Mouth	3,707	0		
GREAT MIAMI RIVER BASIN				
Greenville Cr, Greenville, O	141	20.3		
			20.3	3.5
Greenville Cr, Mouth	201	0		
Mad Riv, Urbana, Ohio	157	40.0		
			15.0	1.6
Mad Riv, Springfield, Ohio	485	24.1		
			24.1	3.0
Mad Riv, Mouth	654	0		
Stillwater Riv, Covington, O	438	32.4		
			17.4	2.4

TABLE 18 (Cont'd)

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
GREAT MIAMI RIVER BASIN (Cont'd)				
Stillwater Riv, West Milton, O	600	15.0		
			15.0	1.8
Stillwater Riv, Mouth	673	0		
E Fk Whitewater Riv, Richmond, Ind	123	38.1		
			38.1	4.6
E Fk Whitewater Riv, Mouth	382	0		
W Fk Whitewater Riv, Connersville, Ind	444	28.0		
			28.0	1.5
W Fk Whitewater Riv, Mouth	857	0		
Whitewater Riv, Main Stem, Brookville, Ind	1,239	35.0		
			25.6	1.4
Whitewater Riv, Main Stem, Harrison, Ohio	1,350	9.4		
			9.4	0.7
Whitewater Riv, Main Stem, Mouth	1,593	0		
Great Miami Riv, Bellefontaine, Ohio	25	160.9		
			28.2	3.6
Great Miami Riv, Sidney, Ohio	545	132.7		
			13.1	2.2
Great Miami Riv, Piqua, Ohio	842	119.6		
			10.2	1.2
Great Miami Riv, Troy, Ohio	970	109.4		
			4.9	0.5
Great Miami Riv, Tipp City, O	984	104.5		
			20.9	2.2
Great Miami Riv, Dayton, Ohio	2,513	83.6		
			7.6	0.6
Great Miami Riv, West Carrolton, Ohio	2,630	76.0		
			8.0	0.6
Great Miami Riv, Miamisburg, O	2,718	68.0		
			6.5	0.5

TABLE 18 (Cont'd)

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
GREAT MIAMI RIVER BASIN (Cont'd)				
Great Miami Riv, Franklin, O	2,731	61.5		
			8.5	0.6
Great Miami Riv, Middletown, O	3,126	53.0		
			17.0	1.3
Great Miami Riv, Hamilton, O	3,639	36.0		
			36.0	3.9
Great Miami Riv, Mouth	5,385	0		
KENTUCKY RIVER BASIN				
N Fk Kentucky Riv, Hazard, Ky	466	106.2		
			102.4	55.5
N Fk Kentucky Riv, u/s Mouth of Middle Fork	1,319	3.8		
SALT RIVER BASIN				
Beech Fork, Bardstown, Ky	669	20.8		
			20.8	3.5
Beech Fork, Mouth	752	0		
Rolling Fork, d/s Mouth of Beech Fk	1,299	20.2		
			20.2	2.0
Rolling Fork, Mouth	1,499	0		
Salt Riv, nr Harrodsburg, Ky	41	100.0		
			88.4	53.1
Salt Riv, u/s Mouth of Rolling Fork	1,256	11.6		
			11.6	7.0
Salt Riv, Mouth	2,920	0		
GREEN RIVER BASIN				
Nolin Riv, d/s Mouth of Valley Cr	283	99.7		
			99.7	8.7
Nolin Riv, Mouth	727	0		
Green Riv, Greensburg, Ky	736	279.8		
			94.3	33.8
Green Riv, u/s Mouth of Nolin Riv	2,758	185.5		

TABLE 18 (Cont'd)

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
WABASH RIVER BASIN				
Salt Cr, Bloomington, Ind	20	56.0		
			56.0	12.6
Salt Cr, Mouth	630	0		
Sugar Cr, Crawfordsville, Ind	509	40.0		
			40.0	5.3
Sugar Cr, Mouth	840	0		
Wildcat Cr, Kokomo, Ind	245	63.0		
			63.0	7.3
Wildcat Cr, Mouth	800	0		
Mississinewa Riv, Marion, Ind	677	36.0		
			36.0	5.5
Mississinewa Riv, Mouth	820	0		
Little Wabash Riv, Carmi, Ill	3,090	30.0		
			30.0	9.1
Little Wabash Riv, Mouth	3,380	0		
E Fk White Riv, Seymour, Ind	2,333	219.2		
			73.4	5.1
E Fk White Riv, Bedford, Ind	3,870	145.8		
			145.8	12.1
E Fk White Riv, Mouth	5,695	0		
White Riv, Winchester, Ind	65	339.5		
			31.5	6.6
White Riv, Muncie, Ind	242	308.0		
			22.3	3.7
White Riv, Anderson, Ind	401	285.7		
			16.7	2.2
White Riv, Noblesville, Ind	837	269.0		
			33.2	3.7
White Riv, Indianapolis, Ind	1,627	235.8		
			33.2	3.3
White Riv, Martinsville, Ind	2,435	202.6		
			154.9	14.0
White Riv, Petersburg, Ind	11,139	47.7		
			47.7	4.9
White Riv, Mouth	11,400	0		
Wabash Riv, Bluffton, Ind	506	421.8		
			12.8	2.1

TABLE 18 (Cont'd)

River and Station	Drainage Area (Sq Mi)	Miles Above Mouth	Distance Between Locations (Miles)	Estimated Time of Travel (Days)
WABASH RIVER BASIN (Cont'd)				
Wabash Riv, Huntington, Ind	710	409.0		
			21.3	1.9
Wabash Riv, Wabash, Ind	1,733	387.7		
			17.2	1.4
Wabash Riv, Peru, Ind	2,655	370.5		
			16.6	1.9
Wabash Riv, Logansport, Ind	3,751	353.9		
			42.0	6.8
Wabash Riv, Lafayette, Ind	7,247	311.9		
			23.9	5.0
Wabash Riv, Attica, Ind	8,528	288.0		
			48.0	11.9
Wabash Riv, Montezuma, Ind	11,100	240.0		
			10.0	2.5
Wabash Riv, Clinton, Ind	11,530	230.0		
			15.6	3.2
Wabash Riv, Terre Haute, Ind	12,200	214.4		
			89.7	10.9
Wabash Riv, Vincennes, Ind	13,700	124.7		
			33.2	3.8
Wabash Riv, Mt. Carmel, Ill	28,600	91.5		
			91.5	12.8
Wabash Riv, Mouth	33,100	0		
CUMBERLAND RIVER BASIN				
Cumberland Riv, Barbourville, Ky	960	635.0		
			45.0	6.2
Cumberland Riv, Williamsburg, Ky	1,607	590.0		

TABLE 19

CORPS OF ENGINEERS RESERVOIRS[1]

PURPOSE; & TOTAL, CONSERVATION, FLOOD & MINIMUM STORAGES

Basin - Reservoir	Status[2]	Purpose[3]	Total Storage (1000 Ac Ft)	Minimum Storage (1000 Ac Ft)	Minimum Storage (Inches)	Flood Storage (Inches): Maj Flood Season	Flood Storage (Inches): Conservation Season	Conservation Storage (1000 Ac Ft): Maj Flood Season	Conservation Storage (1000 Ac Ft): Maximum
ALLEGHENY RIVER BASIN									
Conemaugh	C	F,R	274.0	4.0	0.1	3.7	3.7		
Crooked Creek	C	F,R	93.9	4.5	0.3	6.1 w	5.8 s		
E Br Clarion	C	F,Q,R	84.3	1.0	0.3	10.0 w	4.9 s	44.6 w	64.3 s
Loyalhanna	C	F,R	95.3	2.0	0.1	6.1	6.1		
Mahoning	C	F,R	74.2	4.5	0.3	3.8	3.8		
Tionesta	C	F,R	133.4	7.8	0.3	4.9	4.9		
Allegheny	UC	F,Q,R	1,179.3	24.2	0.2	8.1 w	5.2 s	215.6 w	548.4 s
Union City	UC	F	48.0	3.9	0.3	3.7	3.7		
MONONGAHELA RIVER BASIN									
Tygart	C	F,N,R	287.7	9.7	0.2	4.4 w	2.8 s	0.0 w	99.9 s
Youghiogheny	C	F,Q,R	254.0	5.2	0.2	6.5 w	4.3 s	97.8 w	149.3 s
BEAVER RIVER BASIN									
Berlin	C	F,M,Q,R	91.2	1.8	0.1	4.2 w	2.5 s	33.6 w	56.6 s
Mosquito Creek	C	F,M,Q,R	104.1	2.0	0.4	6.4 w	4.2 s	69.1 w	80.4 s
Shenango	UC	F,Q,R	192.4	11.5	0.5	7.9 w	6.6 s	0.0 w	29.9 s
West Branch	UC	F,M,Q,R	78.7	3.8	0.9	7.7 w	5.1 s	41.7 w	52.9 s
MUSKINGUM RIVER BASIN									
Atwood	C	F,R	26.1			7.0	7.0	23.6	23.6
Beach City	C	F,R	71.7	1.7	0.1	4.4	4.4		
Bolivar	C	F	149.6			5.6	5.6		
Charles Mill	C	F,R	88.0			7.0	7.0	7.4	7.4
Clendening	C	F,R	54.0			7.4	7.4	26.5	26.5
Dillion	C	F,R	274.0	13.1	0.3	6.6	6.6		
Dover	C	F,R	203.0	1.0		4.9	4.9		
Leesville	C	F,R	37.4			7.0	7.0	19.5	19.5
Mohawk	C	F	285.0			6.5	6.5		
Mohicanville	C	F	102.0			7.1	7.1		
Piedmont	C	F,R	65.0			7.0	7.0	33.6	33.6
Pleasant Hill	C	F,R	87.7			7.0	7.0	13.5	13.5
Senecaville	C	F,R	88.5			7.0	7.0	43.5	43.5
Tappan	C	F,R	61.6			7.0	7.0	35.1	35.1
Wills Creek	C	F,R	196.0	6.0	0.2	4.9	4.9		
N Branch	UC	F	15.0	0.4	0.2	6.1	6.1		
HOCKING RIVER BASIN									
Tom Jenkins	C	F,M,R	26.9	3.5	2.0	10.1	10.1	5.8	5.8
KANAWHA RIVER BASIN									
Bluestone	C	F,R	631.0	10.6		2.5 w		20.3 w	25.9 s
Sutton	C	F,R,Q	265.3	4.1	0.1	9.1 w	7.0 s	0.0 w	60.1 s
Summersville	UC	F,R,Q	413.8	23.0	0.5	9.1 w	5.3 s	0.0 w	163.4 s
GUYANDOTTE RIVER BASIN									
Justice	AP	F,R,Q	196.0	22.0	0.8	6.4 w	6.3 s	0.0 w	2.9 s
TWELVEPOLE CREEK BASIN									
East Lynn	AP	F,R	86.0	12.5	1.7	10.0 w	7.8 s	0.0 w	16.5 s
BIG SANDY RIVER BASIN									
Dewey	C	F,R	93.3	12.3	1.1	7.3 w	6.9 s	0.0 w	4.9 s
Fishtrap	UC	F,Q,R	167.4	11.0	0.5	7.4 w	6.1 s	0.0 w	27.9 s
J. W. Flannagan	UC	F,Q,R	106.8	12.0	1.1	8.7 w	7.2 s	0.0 w	15.9 s
North Fork	UC	F,R	11.3	1.9	2.1	10.0	10.0		
LITTLE SANDY RIVER BASIN									
Grayson	UC	F,R,Q	144.0	9.3	0.8	10.9 w	10.1 s	0.0 w	10.7 s
SCIOTO RIVER BASIN									
Delaware	C	F,R,Q	132.0	8.4	0.4	6.1 w	5.8 s	0.0 w	5.6 s
Big Darby	UC	F,R	128.0	4.4	0.2	5.2	5.2		
Deer Creek	UC	F,R	104.0	6.0	0.4	6.6	6.6		
Paint Creek	UC	F,R	154.0	5.0	0.2	4.9	4.9		
Salt Creek	AP	F,R	114.0	10.5	0.7	6.8 w	6.4 s	0.0 w	5.5 s
LITTLE MIAMI RIVER BASIN									
Caesar Creek	AP	F,R,Q,M	167.7	6.2	0.5	12.8	12.8		
East Fork	AP	F,R,Q,M	211.1	17.5	1.0	10.7	10.7		
LICKING RIVER BASIN									
Cave Run	UC	F,R,Q	543.2	37.2	0.8	11.5	11.5		
MILL CREEK BASIN									
West Fork	C	F,R	11.4	1.5	1.0	6.2	6.2		

TABLE 19 (Cont'd)

Basin - Reservoir	Status (2)	Purpose (3)	Total Storage (1000 Ac Ft)	Minimum Storage (1000 Ac Ft)	Minimum Storage (Inches)	Flood Storage (Inches): Maj Flood Season	Flood Storage (Inches): Conservation Season	Conservation Storage (1000 Ac Ft): Maj Flood Season	Conservation Storage (1000 Ac Ft): Maximum
GREAT MIAMI RIVER BASIN									
Brookville	UC	F,R,M	314.7	64.5	3.2	12.4	12.4		
Buck Creek	UC	F,R,Q	32.8	2.4	0.5	6.7	6.7		
KENTUCKY RIVER BASIN									
Buckhorn	C	F,R,Q	168.0	10.3	0.5	7.2 w	6.2 s	0.0 w	21.7 s
Carr Fork	UC	F,R	47.7	2.9	0.9	14.5	14.5		
Eagle Creek	AP	F,R	207.7	14.5	0.9	12.4	12.4		
Red River	AP	F,R	176.2	23.0	2.0	13.1	13.1		
GREEN RIVER BASIN									
Rough River	C	F,R,Q	334.4	20.2	0.8	13.0 w	8.9 s	0.0 w	99.8 s
Barren River	C	F,R,Q	815.2	46.6	0.9	15.3 w	11.2 s	0.0 w	209.8 s
Green River	UC	F,R,Q	723.2	36.1	1.0	15.4 w	13.0 s	89.8 w	126.5 s
Nolin River	C	F,R,Q	609.4	39.3	1.0	15.2 w	11.7 s	0.0 w	130.9 s
WABASH RIVER BASIN									
Cagles Mill	C	F,R	228.1	27.1	1.7	11.1	11.1		
Mansfield	C	F,R,Q	132.8	16.2	1.4	10.1 w	7.2 s	0.0 w	33.1 s
Huntington	UC	F,R	153.1	4.1	0.1	4.0 w	3.7 s	0.0 w	8.4 s
Mississinewa	UC	F,R,Q	368.4	23.3	0.5	8.0 w	6.8 s	0.0 w	51.9 s
Monroe	UC	F,M,R	441.0	22.3	1.0	17.8 w	11.0 s	0.0 w	159.9 s
Salamonie	UC	F,R,Q	263.6	13.1	0.4	8.5 w	6.9 s	0.0 w	47.6 s
CUMBERLAND RIVER BASIN									
Center Hill	C	F,P,R	2,092.0	838.0	7.2	6.5	6.5		
Dale Hollow	C	F,P,R	1,706.0	857.0	17.2	7.1	7.1		
Wolf Creek	C	F,P,R	6,089.0	1,853.0	6.0	6.8	6.8		
Barkley	UC	N,F,P,R	2,081.9	610.1 w	1.3	3.2 w	2.6 s		
J. Percy Priest	UC	F,P,R	652.0	268.0	5.8	7.6 w	5.6 s		
Laurel	UC	F,P,R	443.7	174.3	11.6	5.0	5.0		

FOOTNOTES:

(1) Includes those reservoirs in the 1963 flood control program.

(2) Status (1966):

C - Completed
UC - Under Construction
AP - Advance Planning

(3) Purpose:

F - Flood Control
R - *Recreation*
Q - Quality Release (May be Release of Recreation Pool)
N - Navigation
P - Power
M - Municipal & Industrial Water Supply

s - summer
w - winter

TABLE 20

NATURAL FLOWS AND CORPS OF ENGINEERS RESERVOIR MODIFICATIONS (1)
OF FLOOD CREST DISCHARGE AND STAGE FOR TYPICAL FLOODS ON THE MAIN STEM OHIO

Map Ltr (2)	Location	January 1937 Discharge in 1000 cfs Nat Q	January 1937 Discharge in 1000 cfs Reduction in Q	January 1937 Feet Nat Stage	January 1937 Feet Red in Stage	March 1945 Discharge in 1000 cfs Nat Q	March 1945 Discharge in 1000 cfs Red in Q	March 1945 Feet Nat Stage	March 1945 Feet Red in Stage	April 1948 Discharge in 1000 cfs Nat Q	April 1948 Discharge in 1000 cfs Red in Q	April 1948 Feet Nat Stage	April 1948 Feet Red in Stage	January 1950 Discharge in 1000 cfs Nat Q	January 1950 Discharge in 1000 cfs Red in Q	January 1950 Feet Nat Stage	January 1950 Feet Red in Stage	January-February 1952 Discharge in 1000 cfs Nat Q	January-February 1952 Discharge in 1000 cfs Red in Q	January-February 1952 Feet Nat Stage	January-February 1952 Feet Red in Stage
A	Pittsburgh	351	96	34.5	5.5	382	80	35.7	4.6	378	100	34.8	5.6	195	42	23.3	2.9	339	64	33.1	3.8
C	New Cumberland	392	95	25.5	7.9	413	93	28.0	7.7	414	96	26.5	7.8	208	44	11.7	3.9	407	72	27.7	5.9
D	Wheeling	407	83	48.7	7.0	420	83	49.7	6.7	378	86	48.3	7.1	215	36	32.0	3.7	396	66	47.6	5.3
F	St. Marys	391	74	50.0	6.5	386	71	47.1	6.2	380	77	47.2	7.0	202	25	30.8	2.3	359	36	43.4	3.4
G	Marietta	513	157	55.0	14.5	497	127	52.0	11.6	459	94	52.8	8.6	257	68	36.2	4.2	449	62	48.5	5.7
H	Parkersburg	518	151	55.4	13.8	474	123	51.8	11.2	452	100	53.2	9.0	286	33	35.5	3.5	454	64	48.5	6.0
J	Belleville	542	131	58.6	11.4	480	125	55.0	10.8	478	104	55.5	8.7	283	33	38.2	3.4	423	60	50.3	4.8
K	Pomeroy	543	119	64.5	10.1	475	95	58.2	8.2	473	81	59.1	6.8	290	21	41.2	2.0	418	47	54.4	4.2
L	Pt. Pleasant	543	153	62.7	13.7	508	90	56.0	8.0	520	89	58.1	7.6	312	12	38.3	1.1	478	74	52.3	6.5
M	Huntington	655	145	69.4	9.0	528	72	61.5	5.3	558	49	61.9	3.3	318	10	43.7	1.0	491	56	56.5	4.0
N	Ashland	693	143	73.6	9.1	555	74	65.2	5.4	598	51	66.3	3.6	335	4	47.3	0.5	509	53	59.8	4.0
O	Portsmouth	734	136	74.2	10.4	669	101	65.9	7.7	638	66	65.1	5.1	402	18	47.6	1.4	548	63	58.3	5.0
P	Maysville	776	143	75.3	8.4	642	97	66.5	5.8	637	54	64.5	3.7	397	16	49.5	1.1	547	62	58.2	4.2
Q	Cincinnati	892	156	80.0	9.5	693	84	69.2	5.2	633	46	64.9	3.3	442	13	53.1	1.0	528	62	58.0	4.2
R	Louisville	1,111	112	85.4	3.3	811	70	74.4	3.4	678	40	68.1	2.3	567	25	60.3	2.9	583	67	61.5	4.7
S	Evansville	1,332	142	53.8	1.5	908	87	48.3	0.9	713	49	45.9	0.7	677	31	46.0	0.6	633	59	44.0	1.0
T	Golconda	1,457	123	62.6	1.4	1,008	76	53.2	2.1	820	47	48.2	1.5	982	41	54.5	1.3	743	59	47.3	2.1
U	Metropolis	1,844	541	62.3	8.0	1,297	184	56.0	4.1	885	135	48.4	4.5	1,427	311	58.0	6.5	977	292	48.5	9.2

NOTES:

(1) The natural flow assumes no reservoirs in operation. The modified flow assumes all reservoirs completed, under construction or in advanced planning as of 1 July 1963 were in operation.

(2) See Plate 11 for station locations.

TABLE 21

ULTIMATE AND OPTIMUM FLOWS - STORAGE DEVELOPMENT
AT STREAM GAGING STATIONS OF THE OHIO RIVER BASIN

Stream	Location	Page in 1959 WSP with Description and Data	Period(s) of Record: Years	Period(s) of Record: Total Years	Period(s) of Record: Critical Low Storage Period (3)	Drainage Area (Sq Mi)	Flow - Storage Development: Ultimate: Flow(1) (cfs)	Ultimate: Storage (1000 A/F)	Optimum: Flow (% of Ultimate)	Optimum: Flow (cfs)	Optimum: Storage (% of Ultimate)	Optimum: Storage (1000 A/F)
ALLEGHENY RIVER BASIN												
French Cr	Utica, Pa	28	1932-59	27	Jan 1942	1,028	1,733	2,242	65	1,130	37	830
Clarion Riv	Cooksburg, Pa	35	1938-59	21	Feb 1942	807	1,448	1,200	75	1,090	32	384
Conemaugh Riv	Tunnelton, Pa	50	1939-59	20	Dec 1947	1,358	2,352	2,660	81	1,900	26	691
Kiskiminetas Riv	Vandergrift, Pa	53	1937-59	22	Jan 1945	1,825	3,032	3,140	87	2,640	32	1,000
Allegheny Riv	Eldred, Pa	14	1939-59	20	Feb 1942	550	966	1,116	83	801	30	334
	Red House, N Y	16	1903-59	56	Feb 1942	1,690	2,792	5,280	81	2,260	23	1,210
	Franklin, Pa	30	1914-59	45	Dec 1941	5,982	10,320	14,250	72	7,430	23	3,420
	Kittanning, Pa	42	1904-28; 1934-59	49	Dec 1949	8,973	15,357	22,320	83	12,750	26	5,800
	Natrona, Pa	55	1938-59	21	Jan 1945	11,410	19,490	16,500	88	17,150	39	6,430
MONONGAHELA RIVER BASIN												
West Fork Riv	Enterprise, W Va	75	1907-16; 1933-59	31	Oct 1942	759	1,170	1,524	81	947	24	366
Tygart Valley Riv	Philippi, W Va	64	1940-59	19	Jan 1948	916	1,824	1,710	74	1,350	31	530
	Colfax, W Va	66	1939-59	20	Jan 1948	1,366	2,607	2,400	83	2,160	35	840
Cheat Riv	nr Parsons, W Va	82	1913-59	45	Jan 1948	718	1,656	1,981	88	1,460	36	713
	Rowlesburg, W Va	83	1923-59	36	Jan 1948	972	2,222	2,206	86	1,910	40	882
	nr Pisgah, W Va	86 (2)	1927-58	31	Dec 1947	1,354	2,988	2,649	84	2,510	40	1,060
Youghiogheny Riv	Connellsville, Pa	98	1908-59	51	Dec 1934	1,326	2,503	2,461	81	2,030	34	837
Monongahela Riv	Lock 15, Hoult, W Va	77	1915-26; 1938-59	32	Oct 1942	2,388	4,120	3,805	84	3,460	38	1,450
	Greensboro, Pa	86	1938-59	21	Dec 1947	4,407	8,168	7,320	81	6,620	35	2,560
BEAVER RIVER BASIN												
Shenango Riv	Sharpsville, Pa	121	1938-59	21	Dec 1949	588	743	843	83	616	36	303
Mahoning Riv	Youngstown, Ohio	115	1921-59	38	Dec 1949	899	849	1,935	70	594	23	445
Beaver Riv	Wampum, Pa	122	1914-18; 1932-59	31	Dec 1949	2,235	2,365	3,840	72	1,700	28	1,080
MUSKINGUM RIVER BASIN												
Mohican Riv	Greer, Ohio	160	1921-59	38	Dec 1946	942	887	1,570	77	682	32	502
Tuscarawas Riv	below Dover Dam, nr Dover, Ohio	145	1923-59	36	Jan 1945	1,398	1,385	2,280	81	1,220	26	592
	Newcomerstown, Ohio	153	1921-59	38	Jul 1935	2,436	2,456	3,300	68	1,670	30	990
Licking Riv	Toboso, Ohio	174	1903-05; 1921-59	40	Dec 1936	672	672	1,350	78	524	31	418
Muskingum Riv	nr Coshocton, Ohio	166	1936-59	23	Jan 1956	4,847	4,919	6,360	79	3,890	26	1,650
LITTLE KANAWHA RIVER BASIN												
Hughes Riv	Cisko, W Va	189	1928-31; 1938-59	24	Oct 1942	452	584	1,108	85	496	35	388
Little Kanawha Riv	Glenville, W Va	183	1928-59	31	Dec 1934	386	601	881	76	457	30	264
	Palestine, W Va	188	1939-59	20	Jan 1948	1,515	2,100	2,734	83	1,740	31	848
HOCKING RIVER BASIN												
Hocking Riv	Enterprise, Ohio	193	1930-59	29	Feb 1935	460	439	1,614	72	316	21	338
	Athens, Ohio	196	1915-59	44	Feb 1958	944	985	1,680	75	738	31	520
KANAWHA RIVER BASIN												
Greenbrier Riv	Alderson, W Va	218	1895-1959	64	Dec 1905	1,357	1,993	4,440	81	1,620	21	932
New Riv	Radford, Va	207	1907-15; 1939-59	28	Dec 1956	2,748	3,731	3,120	85	3,170	25	780
	Hinton, W Va	220	1936-59	23	Jan 1948	6,257	7,649	6,120	90	6,880	25	1,530
Gauley Riv	above Belva, W Va	228	1928-59	31	Dec 1947	1,315	2,633	2,940	80	2,110	34	999
Elk Riv	Queen Shoals, W Va	234	1928-59	31	Jan 1948	1,145	1,951	2,202	74	1,440	27	595
			1877-1959	82	Oct 1877	8,367	12,580	38,766	93	11,700	13	5,040
Kanawha Riv	Kanawha Falls, W Va	229	1931-59	29	Jan 1948		11,462	9,801	77	8,830	30	2,940
	Charleston, W Va	235	1939-59	20	Jan 1948	10,419	14,320	15,600	83	11,890	26	4,060
GUYANDOTTE RIVER BASIN												
Guyandotte Riv	Branchland, W Va	242	1915-17; 1929-59	32	Jan 1948	1,226	1,573	2,880	58	912	20	576

Stream	Location	Page in 1959 WSP with Description and Data	Period(s) of Record: Years	Period(s) of Record: Total Years	Period(s) of Record: Critical Low Storage Period (3)	Drainage Area (Sq Mi)	Flow - Storage Development: Ultimate: Flow (1) (cfs)	Ultimate: Storage (1000 A/F)	Optimum: Flow (% of Ultimate)	Optimum: Flow (cfs)	Optimum: Storage (% of Ultimate)	Optimum: Storage (1000 A/F)
BIG SANDY RIVER BASIN												
Tug Fork	nr Kermit, W Va	258	1934-59	25	Jan 1948	1,185	1,331	2,130	52	692	20	426
Levisa Fork	Paintsville, Ky	255	1915-16; 1928-59	32	Jan 1948	2,143	2,342	3,690	56	1,310	22	811
Big Sandy Riv	Louisa, Ky	259	1938-59	21	Jan 1948	3,870	4,163	6,480	62	2,580	26	1,680
LITTLE SANDY RIVER BASIN												
Little Sandy Riv	nr Grayson, Ky	262	1938-59	21	Jan 1948	398	474	862	72	341	32	275
SCIOTO RIVER BASIN												
Big Walnut Cr	Rees, Ohio	277	1921-35; 1938-59	35	Jan 1926	544	493	1,080	64	315	26	280
Paint Cr	nr Bourneville, Ohio	281	1921-36; 1938-59	36	Jan 1945	808	791	1,500	76	601	30	450
Scioto Riv	below O'Shaughnessy Dam, nr Dublin, O	269	1921-59	38	Feb 1945	988	779	1,980	74	576	33	653
	Columbus, Ohio	274	1920-59	39	Jan 1945	1,624	1,353	3,480	78	1,060	35	1,220
	Chillicothe, Ohio	279	1920-59	39	Jan 1945	3,847	3,337	6,990	84	2,800	42	2,940
LITTLE MIAMI RIVER BASIN												
E Fk Little Miami Riv	Perintown, Ohio	296	1915-17; 1925-59	36	Jan 1945	477	549	960	72	395	28	268
Little Miami Riv	Milford, Ohio	295	1915-17; 1925-36; 1938-59	34	Jan 1945	1,195	1,220	2,415	81	988	33	796
LICKING RIVER BASIN												
S Fk Licking Riv	Cynthiana, Ky	305	1938-59	21	Dec 1944	615	734	1,416	78	572	40	566
Licking Riv	Farmers, Ky	298	1938-59	21	Jan 1948	826	1,046	1,716	77	805	33	566
	Catawba, Ky	306	1915-17; 1928-59	33	Dec 1944	3,250	4,091	6,240	84	3,440	40	2,500
GREAT MIAMI RIVER BASIN												
Greenville Cr	nr Bradford, Ohio	318	1930-59	29	Dec 1946	195	173	376	81	140	28	105
Mad Riv	nr Dayton, Ohio	324	1914-59	45	Mar 1947	632	632	1,500	71	448	18	270
E Fk Whitewater Riv	Brookville, Ind	332	1954-59	5	-	382	423	-	-	-	-	-
Whitewater Riv	nr Alpine, Ind	330	1928-59	31	Dec 1949	539	545	990	74	403	39	386
	Brookville, Ind	333	1915-17; 1923-59	38	Jan 1945	1,239	1,287	3,180	78	1,000	24	763
Great Miami Riv	Taylorsville, Ohio	317	1914-17; 1921-59	41	Feb 1945	1,155	1,014	3,450	87	882	27	931
	Dayton, Ohio	325	1913-59	46	Dec 1946	2,513	2,244	7,560	82	1,840	25	1,890
	Hamilton, Ohio	329	1910-18; 1927-59	40	Dec 1946	3,639	3,400	8,040	75	2,550	25	2,010
KENTUCKY RIVER BASIN												
N Fk Kentucky Riv	Jackson, Ky	338	1928-31; 1938-59	24	May 1942	1,101	1,260	2,058	60	756	23	473
Kentucky Riv	Lock 10, nr Winchester, Ky	346	1907-59	52	Nov 1949	3,955	5,175	8,820	75	3,880	31	2,730
	Lock 4, Frankfort, Ky	351	1925-59	34	Jan 1948	5,412	6,928	9,900	66	4,570	27	2,670
SALT RIVER BASIN												
Rolling Fork	nr Boston, Ky	377	1938-59	21	Jan 1948	1,290	1,691	2,850	67	1,130	32	912
Salt Riv	Shepherdsville, Ky	373	1938-59	21	Jan 1942	1,230	1,505	3,210	82	1,230	34	1,090
GREEN RIVER BASIN												
Nolin Riv	Wax, Ky	390	1936-59	23	Jan 1948	600	786	1,680	71	558	26	436
Barren Riv	Bowling Green, Ky	396	1938-59	21	Jan 1948	1,848	2,434	5,040	76	1,850	31	1,560
Rough Riv	nr Dundee, Ky	405	1939-59	20	Dec 1944	757	958	2,472	80	766	31	766
Green Riv	Greensburg, Ky	384	1939-59	20	Dec 1944	736	1,072	2,280	82	879	36	820
WABASH RIVER BASIN												
Embarrass Riv	Ste. Marie, Ill	455	1909-12; 1914-59	48	Jan 1957	1,540	1,227	2,700	83	1,020	35	945
Little Wabash Riv	Carmi, Ill	515	1939-59	20	Feb 1945	3,090	2,587	7,410	83	2,150	33	2,450
Eel Riv	Bowling Green, Ind	485	1931-59	28	Feb 1945	844	854	1,395	72	614	34	474

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WABASH RIVER BASIN (Cont'd)												
E Fk White Riv	Seymour, Ind	496	1927-59	32	Feb 1945	2,333	2,431	5,040	77	1,870	37	1,860
	Shoals, Ind	507	1903-05; 1909-16; 1923-59	45	Feb 1945	4,954	5,458	12,360	76	4,150	34	4,200
White Riv	nr Noblesville, Ind	460	1915-26; 1928-59	42	Jan 1948	814	821	2,250	82	673	30	675
	Indianapolis, Ind	471	1904-05; 1930-59	30	Feb 1945	1,627	1,411	3,270	82	1,160	40	1,310
Wabash Riv	Bluffton, Ind	410	1930-59	29	Dec 1946	506	403	984	83	334	36	354
	Wabash, Ind	415	1923-59	36	Feb 1957	1,733	1,511	4,650	84	1,270	34	1,580
	Logansport, Ind	423	1923-59	36	Dec 1947	3,751	3,317	8,280	79	2,620	31	2,570
	Lafayette, Ind	435	1923-59	36	Dec 1947	7,247	6,401	9,420	83	5,310	29	2,730
	Montezuma, Ind	444	1927-59	32	Feb 1948	11,100	9,422	14,520	81	7,690	32	4,650
CUMBERLAND RIVER BASIN												
Cumberland Riv	Barbourville, Ky	18	1922-31; 1948-59	20	-	960	1,712	-	-	-	-	-
	Cumberland Falls, Ky	20	1907-11; 1914-59	49	Nov 1948	1,977	3,127	6,480	82	2,560	24	1,560
	Carthage, Tenn	40	1922-59	37	Nov 1948	10,700	17,020	23,700	66	11,230	23	5,450

FOOTNOTES:

(1) Equals Average Discharge for Period(s) of Record.

(2) Page in 1958 WSP.

(3) Critical Low Storage Period - Time at Which Greatest Storage Would Have Been Utilized to Maintain Ultimate Flow.

TABLE 22

MONTHLY AVERAGE RUNOFF AS A PERCENT OF THE AVERAGE ANNUAL FLOW FOR SELECTED OHIO RIVER BASIN STATIONS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Allegheny Riv, Natrona, Pa	3.0	4.9	8.0	10.9	11.9	18.7	17.4	10.7	7.2	3.1	1.9	1.9
Monongahela Riv, Charleroi, Pa	2.9	5.3	9.5	13.5	14.2	16.6	12.0	8.2	6.5	4.0	3.9	3.0
Beaver Riv, Wampum, Pa	3.1	3.7	6.5	12.6	14.5	19.5	13.8	8.9	6.6	3.5	3.5	2.4
Kanawha Riv, Charleston, W Va	2.8	4.9	8.8	11.6	13.7	15.5	11.9	9.4	6.2	5.4	5.1	3.6
Scioto Riv, Higby, Ohio	1.2	2.4	5.2	15.4	14.0	17.9	15.9	9.9	7.4	4.3	3.4	2.2
Green Riv, Livermore, Ky	0.9	2.4	6.4	17.4	18.9	17.8	14.9	7.2	4.7	3.2	2.7	2.2
Wabash Riv, Mt. Carmel, Ill	2.5	3.4	5.8	13.9	12.7	13.8	15.9	13.0	7.9	4.7	2.6	2.2
Average	2.3	3.9	7.2	13.6	14.3	17.1	14.6	9.6	6.7	4.0	3.3	2.5

	1 Dec to 1 Apr	1 Apr to 1 Jul	1 Jul to 1 Dec
Allegheny Riv, Natrona, Pa	49.6	35.4	15.0
Monongahela Riv, Charleroi, Pa	54.0	26.9	19.1
Beaver Riv, Wampum, Pa	53.2	29.4	17.4
Kanawha Riv, Charleston, W Va	49.7	27.6	22.7
Scioto Riv, Higby, Ohio	48.9	33.3	17.8
Green Riv, Livermore, Ky	60.7	26.9	12.4
Wabash Riv, Mt. Carmel, Ill	46.3	36.8	16.9
Average	51.9	31.0	17.3

TABLE 23

SUMMARY OF ANNUAL SUSPENDED SEDIMENT YIELDS IN TONS PER SQUARE MILE AND TOTAL ANNUAL DISCHARGES IN MILLION CFS FOR STATIONS IN THE OHIO RIVER BASIN

Physiographic Province	Sub-Basin	Station	D.A. (Sq Mi)	1962		1961		1960		1959		1958		1957		1956		1955		1954		1953		1952	
				Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch	Yield	Disch
APPALACHIAN PLATEAU	MUSKINGUM RIVER BASIN	Muskingum Riv at Dresden, Ohio	5,982	82.5	146.4	122	202.0	95.4	189.1	195	228.5	130	203.4	110	183.1	196	258.7	103	164.1	47.0	82.0	51.4	118.0	-	-
	HOCKING RIVER BASIN	Hocking Riv at Athens, Ohio	944	167	25.8	250	34.7	89.3	22.3	190	27.4	310	38.5	120	21.8	-	-	-	-	-	-	-	-	-	-
	TYGARTS CREEK BASIN	Tygarts Creek nr Greenup, Ky	242	403	10.2	451	13.5	365	7.8	117	5.4	366	13.5	254	10.0	-	-	-	-	-	-	-	-	-	-
	CUMBERLAND RIVER BASIN	Cumberland Riv at Williamsburg, Ky	1,607	473	94.5	410	86.4	425	94.2	315	56.6	391	108.4	376	91.7	374	95.0	351	83.1	101	46.9	-	-	-	-
	LICKING RIVER BASIN	Licking Riv at Farmers, Ky	831	357	47.5	328	47.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	BIG SANDY RIVER BASIN	Levisa Fork at Paintsville, Ky	2,143	459	101.8	475	1,099	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CENTRAL LOWLAND	GREAT MIAMI RIVER BASIN	Great Miami Riv at Dayton, Ohio	2,513	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	87.1	44.7	241	90.3
	LITTLE MIAMI RIVER BASIN	Little Miami Riv nr Oldtown, Ohio	129	-	-	-	-	-	-	-	-	172	5.3	103	2.8	97.8	3.5	76.1	-	117	.9	25.0	1.7	-	-
		Little Miami Riv nr Selma, Ohio	50.6	-	-	-	-	-	-	-	-	209	2.3	101	1.1	121	1.4	90.4	11	6.8	.3	24.0	.6	-	-
		North Fk Little Miami Riv nr Pitchin, Ohio	29.1	-	-	-	-	-	-	-	-	98.4	1.1	44.7	0.5	46.5	.8	38.5	.5	8.3	.2	17.8	.3	-	-
		Todd Fork at Roachester, Ohio	219	-	-	-	-	-	-	-	-	917	11.7	619	8.1	713	7.9	518	5.9	341	2.9	272	4.0	-	-
		Massie Creek at Wilberforce, Ohio	64.3	-	-	-	-	-	-	-	-	451	3.2	139	1.8	151	2.0	101	1.1	15.3	.3	27.9	.8	-	-
		North Fk Massie Creek at Cedarville, Ohio	25.6	-	-	-	-	-	-	-	-	239	1.4	91.8	.8	83.9	.9	105	.5	-	-	-	-	-	-
		South Fk Massie Creek at Cedarville, Ohio	20.2	-	-	-	-	-	-	-	-	178	1.0	139	.8	113	.6	91.9	.3	-	-	-	-	-	-
	SCIOTO RIVER BASIN	Scioto Riv at Higby, Ohio	5,129	180	121.1	223	143.0	119	981.0	381	151.8	297	190.0	230	139.1	269	145.2	204	100.1	74.9	43.1	-	-	-	-
		Scioto Riv at Prospect, Ohio	571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40.3	6.8	203	18.8
		Big Walnut Creek at Central College, Ohio	191	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	64.9	2.2	280	7.9
		Paint Creek nr Bourneville, Ohio	808	298	25.2	387	28.0	171	17.5	392	24.6	485	53.9	407	26.4	-	-	-	-	-	-	-	-	-	-
INTERIOR LOW PLATEAUS	LICKING RIVER BASIN	Licking Riv at McKinneysburg, Ky	2,280	541	112.0	550	127.0	414	79.9	289	58.2	499	112.9	543	94.5	1,004	108.0	844	1,142	134	25.8	268	65.6	-	-
	KENTUCKY RIVER BASIN	Kentucky Riv at Frankfort, Ky	5,412	645	286.0	298	264.0	254	216.5	135	128.3	414	296.0	539	239.5	627	248.8	703	249.8	58.6	77.1	203	178.7	-	-
	SALT RIVER BASIN	Salt Riv at Shepherdsville, Ky	1,190	-	-	751	67.2	840	49.0	291	26.4	712	61.8	573	39.6	720	44.2	1,101	50.7	243	10.9	484	38.1	-	-
		Plum Creek at Waterford, Ky	31.9	-	-	1,890	2.1	2,410	1.6	1,080	0.7	1,434	1.7	787	1.0	886	1.0	1,732	1.3	-	-	-	-	-	-
	GREEN RIVER BASIN	Green Riv at Munfordville, Ky	1,493	630	107.4	288	82.0	254	74.0	204	54.5	461	111.0	323	82.0	440	91.2	445	84.2	176	33.2	214	55.3	640	123.9
		Barren Riv at Bowling Green, Ky	1,358	-	-	-	-	220	70.7	186	49.8	217	91.9	319	85.4	292	740.0	316	78.7	132	36.2	-	-	-	-
		Rough Riv at Falls of Rough, Ky	500	-	-	-	-	-	-	-	-	-	-	-	-	577	20.8	546	19.5	78.9	5.5	280	17.1	-	-
	TRADEWATER RIVER BASIN	Tradewater Riv at Olney, Ky	246	82.5	12.2	69.7	12.0	73.4	8.6	57	5.7	78.9	16.5	62.8	10.4	64.4	8.3	87.1	8.9	47.7	4.2	68.0	9.3	-	-

TABLE 24

SUMMARY OF ANNUAL RESERVOIR SEDIMENTATION RATES OF RESERVOIRS FOR PHYSIOGRAPHIC PROVINCES OF THE OHIO RIVER BASIN

Physiographic Province	Sub-Basin	Reservoir	Stream	Silt Contributing D.A. (Sq Mi)	Annual Sedimentation Rate (Ac Ft)	Annual Sedimentation Rate (Ac Ft per Sq Mi)	Period of Survey (Years)
Appalachian Plateau	Allegheny	Crooked Creek	Crooked Creek	274	16.4	0.06	5.4
		Loyalhanna Creek	Loyalhanna Creek	285	142.5	0.50	11.3
		Mahoning Creek	Mahoning Creek	336	53.8	0.16	7.3
		Tionesta Creek	Tionesta Creek	474	94.8	0.20	8.6
	Beaver	Berlin	Mahoning River	246	319.8	1.30	8.4
		Lake Milton	Mahoning River	277.4	233.0	0.84	25.0
		Meander Creek	Meander Creek	81.8	28.6	0.35	20.0
	Monongahela	Bridgeport (Upper)	Jacobs Creek	32.4	3.2	0.10	50.6
		Tygart	Tygart Valley River	1,178	94.2	0.08	21.5
	Muskingum	Atwood	Indian Fork, Conotton Creek	66.2	19.2	0.29	6.7
		Barberton	Wolf Creek	28	30.8	1.10	12
		Buckeye Lake	South Fork, Licking River	45.1 (1)	38.8	0.86	107
		Charles Mill	Black Fork, Mohican River	207	155.3	0.75	16.0
		Leesville	McGuire Creek	45.7	3.2	0.07	3.3
		Pleasant Hill	Clear Fork, Mohican River	195	44.9	0.23	6.3
		Senecaville	Seneca Fork, Wills Creek	113	100.6	0.89	8.3
		Stoney Lake	McGuire Creek	11.7	2.8	0.24	21.4
	Scioto	Lake White	Pee Dee Creek	36.9	48.3	1.31	16.0
	Tennessee	Caryville	Cove Creek	35.6	20.6	0.58	10.2
		Guntersville (2)	Tennessee River	2,550	1,683	0.66	15.5
		Wilson (3)	Tennessee River	1,135	136.2	0.12	22.5
	Minor Ohio Riv Trib	Jackson Lake	Black Fork River	18.4	9.9	0.54	11
		Roosevelt Lake	Turkey Creek	15.8	2.2	0.14	15.3
		Vesuvius Lake	Storms Creek	10.7	7.5	0.70	12
Central Lowland	Little Miami	Cowan Lake	Cowan Creek	48.5	41.2	0.85	13
	Great Miami	Englewood (4)	Stillwater River	639	23.5	0.04	15
		Germantown (4)	Twin Creek	264	25.5	0.10	15
		Loramie Lake	Loramie Creek	77.4	8.5	0.11	120
	Scioto	Delaware	Olentangy River	379	56.9	0.15	9.3
		Griggs (5)	Scioto River	1,052	21.4	0.02	30
		Madison Lake	Deer Creek	57	14.3	0.25	7.6
		O'Shaughnessy	Scioto River	987	108.6	0.11	26
	Wabash	Cagles Mill	Mill Creek	287	159.6	0.56	9.2
		Greendale Lake	Connor's Branch	25	3.5	0.14	13.1
		Lake Charleston	Embarrass River	811	65.4	0.08	13.0
		Shafer Lake	Tippecanoe River	1,698	39.6	0.02	17.2
		Vermilion Lake	North Fork, Vermilion River	266	47.9	0.18	25.3
	Minor Ohio Riv Trib	Grant Lake	Sterling River	25	18.0	0.72	1.6
Interior Low Plateaus	Cumberland	Great Falls	Caney Fork River	1,671	117.0	0.07	37.0
	Kentucky	Herrington Lake	Dix River	431	202.6	0.47	16
	Tennessee	Kentucky (6)	Tennessee River	7,131	6,489	0.91	9.9
		Wheeler (7)	Tennessee River	5,033	905.9	0.18	19.7

FOOTNOTES:

(1) D.A. has been 115 sq mi (net) part of time in past, when fed partly by feeder from South Fork Kirkerville River. Originally, the lake was a natural lake used as a feeder for the Ohio Canal System.

(2) Downstream from Hales Bar Dam.

(3) Downstream from Wilson Dam.

(4) Miami Conservancy District Retarding Basin.

(5) Downstream from O'Shaughnessy Dam.

(6) Downstream from Pickwick Landing Dam.

(7) Downstream from Wheeler Dam.

TABLE 25

STAGE AND DISCHARGE DATA - FROM HOUSE DOCUMENT 306, 1935

Station	Zero Gage msl (1)	Maximum Flood of Record		1913 Flood		Estimated Maximum Probable Flood (2)	
		Date	Peak Gage Height (Feet)	Peak Gage Height (Feet)	Peak Discharge (cfs)	Peak Gage Height (Feet)	Peak Discharge (cfs)
Pittsburgh, Pa	697.2	3/15/07	35.5	30.4	360,000	43.5	670,000
L&D 12 (Wheeling, W Va)	610.6	2/7/84	52.1	51.1	478,000	62.0	740,000
Parkersburg, W Va	561.6	3/29/13	58.9	58.9	654,000	73.0	980,000
L&D 29 (Ashland, Ky)	484.8	3/31/13	68.3	68.3	706,000	82.0	1,070,000
L&D 37 (Cincinnati, Ohio)	428.8	2/18/84	65.5	65.0	815,000	78.0	1,200,000
L&D 41 (Louisville, Ky)	372.0	2/16/84	76.0	74.6	902,000	85.0	1,227,000
Evansville, Ind	329.2	2/19/84	48.8	48.4	900,000	53.0	1,224,000
Shawneetown, Ill	309.1	4/5/13	58.9	58.9	1,198,000	61.0	1,306,000
Paducah, Ky	286.3	4/7/13	54.3	54.3	1,583,000	59.0	1,920,000

(1) Gage locations and gage zero elevations may have changed. See Table 13 for current data.

(2) This term represents an estimated project flood of about the magnitude of standard project flood under present day criteria.

TABLE 26

STAGE AND DISCHARGE DATA - FROM 1937 STUDY

Station	Zero Gage (msl) (1)	Maximum Flood of Record(1)			Project Flood	
		Date	Peak Gage Height	Peak Discharge (cfs)	Peak Gage Height	Peak Discharge (cfs)
Pittsburgh, Pa	694.0	3/18/36	46.0	560,000	51.0	675,000
L&D 12 (Wheeling, W Va)	610.8	3/19/36	55.2	492,000	66.0	650,000
Parkersburg, W Va	561.9	3/29/13	58.9	650,000	67.0	810,000
L&D 28 (Huntington, W Va)	490.2	1/27/37	69.4	660,000	75.0	780,000
L&D 29 (Ashland, Ky)	483.1	1/27/37	73.6	740,000	80.0	870,000
Portsmouth, Ohio	470.9	1/27/37	74.2	820,000	83.0	950,000
Cincinnati, Ohio	428.8	1/26/37	80.0	930,000	84.0	1,020,000
L&D 41 (Louisville, Ky)	374.0	1/27/37	85.4	1,200,000	87.0	1,300,000
Evansville, Ind	329.2	1/31/37	53.8	1,300,000	55.5	1,350,000
Paducah, Ky	286.3	2/2/37	60.6	1,850,000	64.5	2,200,000

(1) Data is for 1937 conditions. Gage locations and/or zero elevations may have changed. See Table 13 for current data.

TABLE 27

NATURAL AND MODIFIED PEAK STAGE DATA - FROM 1937 STUDY

Station	Flood Stage (Feet)	Maximum Flood of Record (Stage in Feet)	Project Flood	
			Peak Stage (Feet)	Modified Peak Stage (Feet)
Pittsburgh, Pa	25	46.0	51.0	39.5
L&D 8 (Wellsville, O)	35	51.1	61.0	50.7
L&D 12 (Wheeling, W Va)	36	55.2	66.0	55.2
Parkersburg, W Va	36	58.9	67.0	56.4
L&D 28 (Huntington, W Va)	50	69.4	75.0	67.6
L&D 29 (Ashland, Ky)	51	73.6	80.0	72.5
Portsmouth, Ohio	50	74.2	83.0	74.6
Cincinnati, Ohio	52	80.0	84.0	79.6
L&D 41 (Lower Gage, Louisville, Ky)	55	85.4	87.0	84.0
Evansville, Ind	42	53.8	55.5	53.4
Paducah, Ky	39	60.6	64.5	61.5

TABLE 28

OHIO RIVER PROJECT FLOOD STUDY
MAJOR STORM DATA

Storm						Maximum Average Rainfall Depth in Inches																Time Interval in Days *		Storm Used in Hypo-Flood Number
			Total Area in 1000 Sq. Mi.	Minimum Isohyet in Inches	Total Duration in Hours	20,000 Square Miles				50,000 Square Miles				100,000 Square Miles				Total Area				From	To	
Assign-ment No.	Date	Location				24 Hours	48 Hours	72 Hours	Total Duration	24 Hours	48 Hours	72 Hours	Total Duration	24 Hours	48 Hours	72 Hours	Total Duration	24 Hours	48 Hours	72 Hours	Total Duration	End of Preceding Storm	Beginning of Next Storm	
OR 4-1	25 Jul- 3 Aug 1875	Ill., Ind., Ohio	82.8	5	240	3.3	4.2	4.6	9.3	2.6	3.8	4.3	8.3	-	-	-	-	2.0	3.2	3.8	7.3			68
OR 5-11	2-18 Feb 1883	Ark. to New York	446.0	4	384	3.5	4.1	4.1	9.4	3.0	3.7	3.7	8.5	2.6	3.3	3.3	7.8	1.2	1.9	1.9	5.4	3	3	3
	3-14 Feb 1884	Ohio River Basin *	203.9	3	264				7.0				6.5				5.9				4.7			
MR 1-1	16-20 Dec 1895	Okla., Mo., Ill.	110.0	4	96	4.5	7.7	8.4	8.4	3.3	6.2	7.1	7.1	2.6	5.0	5.7	5.8	2.5	4.8	5.5	5.6			
UMV 2-4	24-26 Mar 1904	Ark., Mo., Ill., Ind.	103.0	2	42	4.7	-	-	5.4	3.7	-	-	4.5	-	-	-	-	2.8	-	-	3.6	3	4	21-23
LMV 1-4	17-21 Nov 1906	La., Miss., Ark., Tenn.	150.0	5	108	5.8	6.9	9.0	11.9	4.6	5.3	7.0	9.7	3.4	4.0	5.3	7.7	2.7	3.2	4.3	6.5			
LMV 1-5	1 - 3 Jan 1907	Ark., Tenn., Mo., Ill., Ind., Ky.	61.2	3	48	4.7	6.4	-	6.4	3.0	5.2	-	5.2	-	-	-	-	2.6	4.8	-	4.8		3	4
OR 1-7 #	9-14 Mar 1907	Ill., Ind., Ky., Ohio, W. Va., Pa.	133.0	2	105				5.2				4.4				3.6				3.3	3		20
OR 4-8	3 - 6 Oct 1910	Ark. to Ohio	70.0	5	90	6.0	8.8	10.7	10.7	5.4	7.4	9.1	9.1	-	-	-	-	4.9	6.5	8.2	8.2		3	90
LMV 1-9	10-12 Jan 1913	Ark., Ky., Mo., Tenn.	70.0	3	48	4.4	5.8	-	5.8	3.6	4.9	-	4.9	-	-	-	-	3.2	4.5	-	4.5	3	3	4
OR 1-15	23-27 Mar 1913	Ark. to New York	160.0	2	120	4.9	6.9	8.1	9.2	4.1	5.8	7.1	8.2	3.2	4.8	6.0	7.0	2.5	4.0	5.1	6.1	3-4	3	21, 22, 23, 24, 40
MR 2-13	26-31 Jan 1916	Okla., Ark., Mo., Ill., Ind.	150.0	5	126	3.3	4.8	5.8	7.4	2.4	3.9	4.9	6.7	1.9	3.2	4.2	6.1	1.6	2.8	3.8	5.4	3	4	
UMV 3-68	7-12 Oct 1919	Texas to Ohio	220.0	2	120	3.4	4.0	5.2	6.5	2.7	3.1	4.1	5.4	1.7	2.5	3.3	4.6	1.2	1.7	2.5	3.6			
LMVI 1-13A	25-28 Oct 1919	Okla., Kan., Mo., Ill., Ind.	84.0	3	60	4.2	7.1	-	7.5	3.0	5.5	-	6.1	-	-	-	-	2.3	4.5	-	5.1			
LMV 2-22	6-11 Jan 1930	Ark., Miss., Tenn.	70.0	3	114	4.2	7.2	8.4	8.4	3.4	6.0	7.0	7.1	-	-	-	-	3.1	5.2	6.2	6.3	4	2	2
	18-21 Mar 1933	Ohio River Basin *	203.9	1	96				4.0				3.7				3.4				2.5			
SW 2-10	15-20 Dec 1933	Ark., Tex., Mo., Ill., Ky., Tenn.	97.0	3	114	3.1	4.2	5.8	6.6	2.3	3.3	4.6	5.5	-	-	-	-	1.5	2.8	3.7	4.6			
LMV 1-19	18-21 Jan 1935	Ark., Ky., Tenn., Miss.	98.5	3	84	4.6	7.4	8.4	8.6	3.2	5.7	6.5	6.8	-	-	-	-	2.2	4.3	5.1	5.4	5	3	
SA 1-27	16-21 Mar 1936	Va., W. Va., Pa., Md.	85.7	3	126	3.4	4.4	5.1	5.9	2.9	3.7	4.3	5.2	-	-	-	-	2.6	3.3	3.7	4.6	3	2, 3-4	20, 22, 22 A-B, 30
OR 5-6	5-25 Jan 1937	Ark., Tenn., Ky., Ind., Ohio	133.0	10	486	4.0	7.1	8.7	19.6	3.4	6.1	7.6	17.8	2.7	4.7	6.2	15.6	2.2	4.0	5.4	14.4	3	5	1, 2, 3
SA 5-13	24-28 Apr 1937	Va., N.C., Md., Pa.	20.0	3	114	3.7	5.2	5.8	5.9	-	-	-	-	-	-	-	-	3.7	5.2	5.8	5.9	2		30
UMV 3-20	30 Sep- 7 Oct 1941	Texas to Mich.	193.0	3	186	4.4	4.7	5.9	7.5	3.4	4.0	5.2	7.0	2.4	3.2	4.4	6.5	1.7	2.3	3.3	5.2	3	2	90
OR 9-24 #	27-30 Dec 1942	Ohio River Basin *	203.9	0.5	72				5.8				4.8				4.0				2.7			
SW 2-20	6-12 May 1943	N. Tex. to Great Lakes	212.0	2	144	6.1	10.0	10.8	11.1	4.6	7.7	8.3	8.9	3.4	5.8	6.4	7.3	2.2	3.7	4.4	5.5	3	3	40-50
SW 2-21	12-20 May 1943	Okla. to Great Lakes	200.0	3	192	4.2	6.9	9.1	10.1	3.4	5.3	7.0	8.2	2.6	4.1	5.4	6.8	1.7	2.7	3.8	5.2	3	3	50
OR 5-12 #	25 Feb- 7 Mar 1945	Ohio River Basin *	203.9	1	225				9.6				8.1				6.6				4.6			
	3-16 Jan 1950	Ohio River Basin *	203.9	1	336	3.0	4.4	5.0	10.3	2.2	3.5	4.2	9.5	1.5	2.5	3.2	8.6	0.6	1.1	1.7	6.2	4		1
	23 Jan-10 Feb 1950	Ohio River Basin *	203.9	2	456				9.6				8.1				6.9				5.1			

Storm Study not Completed

Furnished by Weather Bureau

* Rainfall Data Computed for Portion of Storm Within Boundries of Ohio River Basin

TABLE 29

COMPARATIVE DISCHARGE DATA - HYPOTHETICAL FLOODS

Flood	Storm Combination	Natural Peak Discharge in 1,000 CFS										
		Pitts-burgh	Wheel-ing L&D 12	St. Marys	Pom-eroy	Hunt-ington L&D 28	Mays-ville L&D 33	Cincin-nati	Louis-ville L&D 41	Evans-ville	Gol-conda L&D 51	Metrop-olis L&D 52
Maximum of Record	Mar 1936, Pittsburgh to Wheeling Mar 1913, St. Marys to Pomeroy Jan 1937, Huntington to Metropolis	570	470	500	630	660	820	890	1,100	1,410	1,470	1,850
Hypo-Floods												
OR-1	5-24 Jan 1937 (T) & 3-16 Jan 1950	625	750	780	1,090	1,300	1,470	1,620	1,760	1,970	2,190	2,400
OR-2	5-24 Jan 1937 & 7-11 Jan 1930 (T)	220	280	300	480	480	550	610	860	1,210	1,310	1,740
OR-3	2-7 Feb 1883 & 20-25 Jan 1937	250	290	300	460	490	580	600	880	1,180	1,110	1,500
OR-4	1-3 Jan 1907 (T) & 10-11 Jan 1913 (T)	280	260	290	340	500	610	590	620	630	620	-
OR-5A	5-24 Jan 1937 (T) & 3-16 Jan 1950	540	660	680	960	1,120	1,280	1,385	1,575	1,750	2,010	2,280
OR-20	16-18 Mar 1936 & 12-15 Mar 1907 (T)	510	500	510	530	490	540	530	600	-	-	-
OR-21	23-26 Mar 1913 (T) & 24-26 Mar 1904 (T)	750	820	850	990	1,145	1,240	1,350	1,440	1,380	1,420	1,720
OR-22A	16-18 Mar 1936 & 16-18 Mar 1936	510	530	550	540	630	700	680	640	-	-	-
OR-22B	16-18 Mar 1936 & 16-18 Mar 1936 (T)	510	560	600	670	700	780	760	740	-	-	-
OR-23	23-26 Mar 1913 & 24-26 Mar 1904 (T)	290	390	410	570	600	840	790	860	940	1,030	1,540
OR-24	23-26 Mar 1913 & 24-27 Mar 1913 (T)	640	710	700	900	1,120	1,210	1,270	1,330	1,380	1,590	2,000
OR-30	16-18 Mar 1936 (T) & 25-29 Apr 1937 (T)	590	620	630	630	660	650	640	-	-	-	-
OR-40	23-26 Mar 1913 & 6-12 May 1943 (T)	350	410	460	570	590	740	750	1,180	1,380	1,400	1,610
OR-50	6-12 May 1943 (T) & 15-20 May 1943 (T)	320	340	360	390	630	730	760	930	1,080	990	1,540
OR-90	3-6 Oct 1910 (T) & 2-7 Oct 1941 (T)	350	450	440	550	570	770	780	820	850	920	1,070

NOTE: (T) - Storm Transposed.

TABLE 30

OHIO RIVER BASIN RESERVOIR DATA
AS USED FOR THE STANDARD PROJECT FLOOD, NOV 1962

Tributary Basin	Number of Reservoirs November 1962		Drainage Area Controlled (Square Miles)		Usable Flood Control Storage (1000 Acre Feet)	
	Completed	Under Construction & Advance Planning	Completed	Under Construction & Advance Planning	Completed	Under Construction & Advance Planning
Allegheny Riv	6	1	2,808	2,180	677.5	940.0
Monongahela Riv	2	0	1,618	0	422.3	0.0
Beaver Riv	2	2	346	670	89.9	178.4
Muskingum Riv	15	0	5,015	0	1,588.9	0.0
Little Kanawha Riv	0	0	0	0	0.0	0.0
Hocking Riv	1	0	33	0	17.6	0.0
Kanawha Riv	2	1	5,102	803	859.4	390.8
Guyandotte Riv	0	0	0	0	0.0	0.0
Twelvepole Cr	0	0	0	0	0.0	0.0
Big Sandy Riv	1	3	207	635	81.0	260.6
Little Sandy Riv	0	0	0	0	0.0	0.0
Scioto Riv	1	0	381	0	123.6	0.0
Little Miami Riv	0	0	0	0	0.0	0.0
Licking Riv	0	0	0	0	0.0	0.0
Mill Cr	1	0	30	0	9.9	0.0
Whitewater Riv	0	0	0	0	0.0	0.0
Kentucky Riv (1)	1	0	409	0	157.7	0.0
Green Riv (2)	1	3	454	2,343	314.2	2,011.5
Wabash Riv	2	4	503	2,510	317.6	999.8
Cumberland Riv	3	1	8,919	8,720	3,209.0	1,471.8
Total - Corps of Engineers Projects	38	15	25,825	17,861	7,668.6	6,252.9
Tennessee Riv	18	0	40,200	0	11,814.2	0.0
Total - Ohio Riv Basin	56	15	66,025	17,861	19,682.8	6,252.9

(1) Does not include Jessamine Cr Reservoir.

(2) Does not include Mining City Reservoir.

TABLE 31

NATURAL AND MODIFIED PEAK STAGES - HYPOTHETICAL FLOODS

Station	Maximum Flood of Record	MRC-58A Natural	MRC-58A Modified	OR-1 Natural	OR-1 Modified	OR-5A Natural	OR-5A Modified	OR-21 Natural	OR-21 Modified	OR-24 Natural	OR-24 Modified
Pittsburgh	46.0			48.8	44.9	44.5	40.7	55.2	44.6	49.4	40.7
L&D 12 (Wheeling)	55.2			68.5	64.4	64.0	60.0	71.1	61.5	66.2	59.0
St. Marys	54.8			68.3	65.2	64.8	61.8	71.0	65.6	65.5	60.4
Pomeroy	67.0			89.3	84.6	84.0	79.5	84.9	76.9	80.7	74.4
L&D 28 (Huntington)	69.4			89.8	84.8	84.6	79.8	85.5	77.5	84.5	78.5
L&D 33 (Maysville)	75.3			96.1	89.7	90.2	84.5	88.5	80.8	87.5	81.7
Cincinnati	80.0			103.0	97.5	95.7	90.8	94.6	87.7	92.0	86.0
L&D 41 (Louisville)	85.4			102.0	97.5	97.5	93.1	94.0	90.0	91.6	88.3
Evansville	53.8			59.8	58.2	58.0	56.5	55.1	53.8	55.0	53.8
L&D 51 (Golconda)	62.8			76.0	73.5	73.5	70.7	62.3	59.7	65.8	63.0
L&D 52 (Metropolis	62.5	69.0	64.5	68.7	64.2	66.6	62.8	61.3	55.0	64.4	60.0

NOTES: Modification by reservoirs completed, under construction or in advanced planning as of 1 July 1963.

Standard Project Floods selected are underscored.

TABLE 32

COMPARATIVE DATA

STANDARD PROJECT FLOOD AND DERIVED FREQUENCY DATA

Location	Drainage Area (1000 Sq Mi)	SPF Peak Discharge (1000 cfs)	CFS Per Square Mile: Standard Project Flood	Computed Recurrence Intervals: 2-Year	10-Year	100-Year
Pittsburgh	19.1	750	39.3	13.1	18.9	26.6
L&D 12 (Wheeling)	24.7	820	33.2	10.9	15.6	21.9
Pomeroy	40.5	990	24.4	8.4	11.5	15.7
L&D 28 (Huntington)	55.9	1,145	20.5	6.7	9.6	13.0
Cincinnati	76.6	1,385	18.1	5.8	8.3	11.2
L&D 41 (Louisville)	91.2	1,575	17.3	5.4	7.7	10.4
Evansville	107.0	1,750	16.4	5.1	7.3	9.8
L&D 51 (Golconda)	142.9	2,010	14.1	4.7	6.6	8.8
L&D 52 (Metropolis)	203.0	2,460	12.1	4.3	5.9	8.0

ISOTHERMS
OHIO RIVER BASIN

MEAN DAILY MINIMUM TEMPERATURE (°F.), JANUARY.

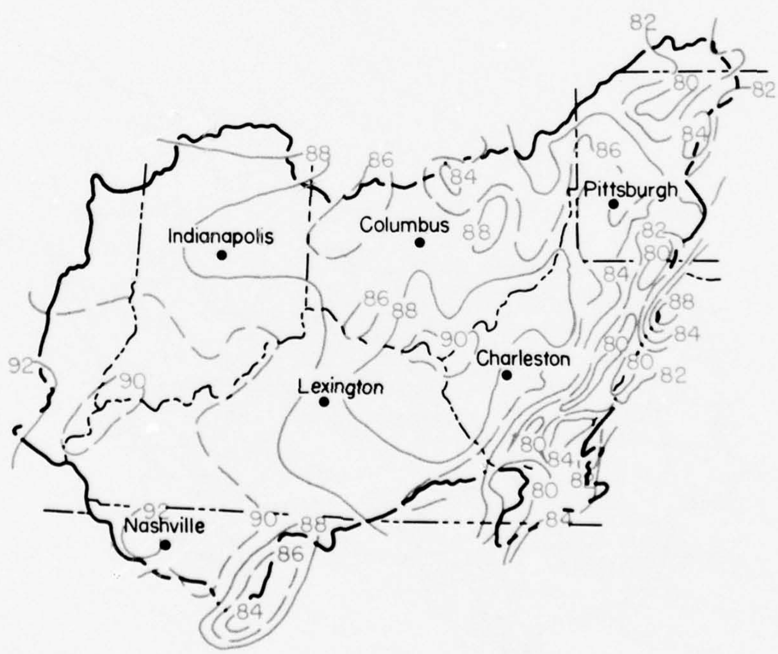
MEAN DAILY MAXIMUM TEMPERATURE (°F.), JANUARY.

SOURCE: Climatological Maps from National Atlas of United States
Published by U. S. Weather Bureau

PLATE 1a

ISOTHERMS
OHIO RIVER BASIN

MEAN DAILY MINIMUM TEMPERATURE (°F.), JULY

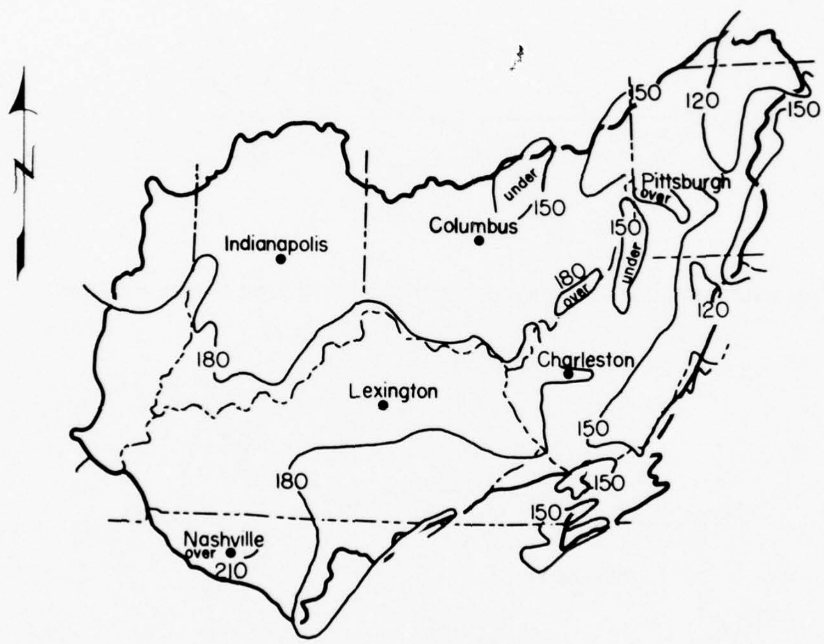


MEAN DAILY MAXIMUM TEMPERATURE (°F.), JULY

SOURCE: Climatological Maps from National Atlas of United States
Published by U. S. Weather Bureau

PLATE 1b

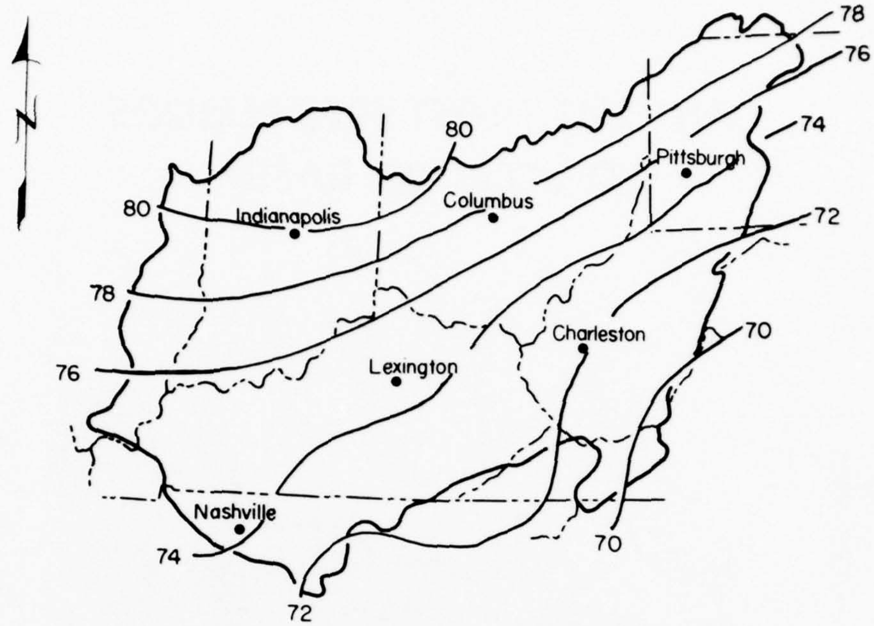
ANNUAL FROST FREE PERIODS
OHIO RIVER BASIN



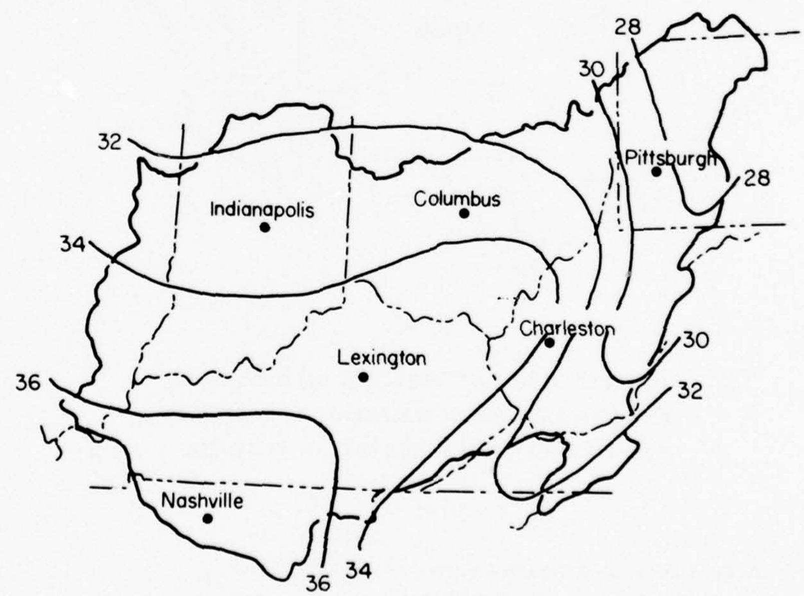
MEAN LENGTH OF FREEZE-FREE PERIOD (DAYS) BETWEEN LAST 32° F. TEMPERATURE IN SPRING AND FIRST 32° F. TEMPERATURE IN AUTUMN.

SOURCE: Climatological Maps from National Atlas of United States
Published by U. S. Weather Bureau

EVAPORATION RATES
OHIO RIVER BASIN



MEAN MAY THROUGH OCTOBER EVAPORATION IN PERCENT OF ANNUAL.



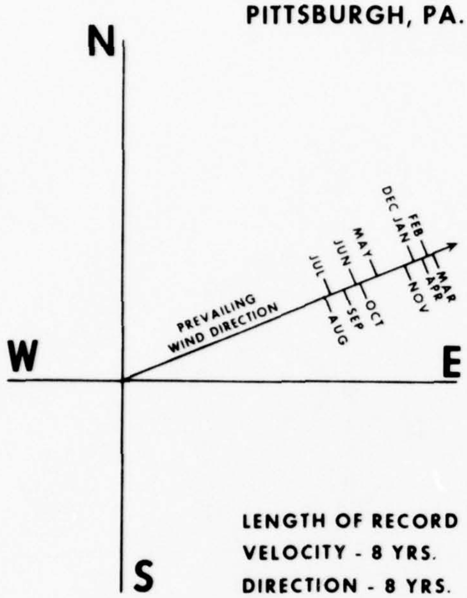
MEAN ANNUAL LAKE EVAPORATION (INCHES).

NOTE-Seasonal percent based primarily on pan data but limited testing indicates that the map is equally applicable to lake evaporation assuming no change in heat storage.

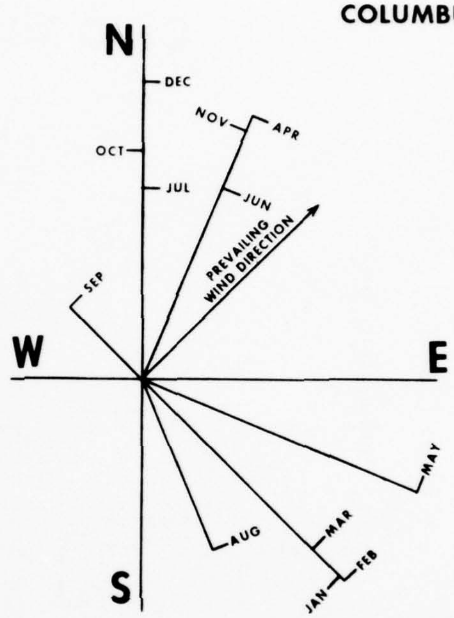
SOURCE: Climatological Maps from National Atlas of United States Published by U. S. Weather Bureau

WIND ROSES
VELOCITY & PREVAILING DIRECTION
FOR SELECTED OHIO RIVER BASIN STATIONS

PITTSBURGH, PA.

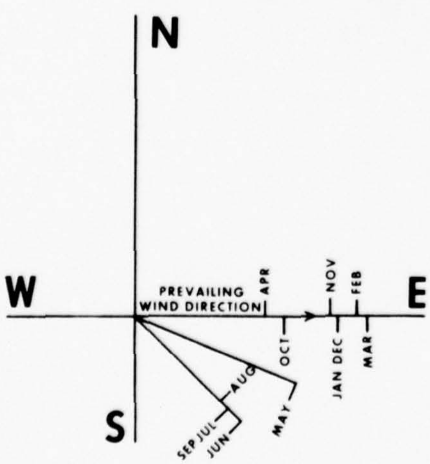


COLUMBUS, OHIO



LENGTH OF RECORD - VELOCITY - 52 YRS.
DIRECTION - 8 YRS.

ELKINS, W. VA.



LENGTH OF RECORD - VELOCITY - 24 YRS.
DIRECTION - 24 YRS.

NASHVILLE, TENN.

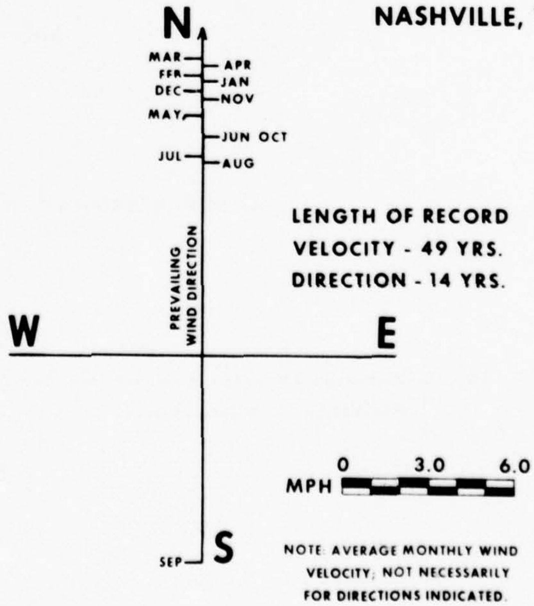
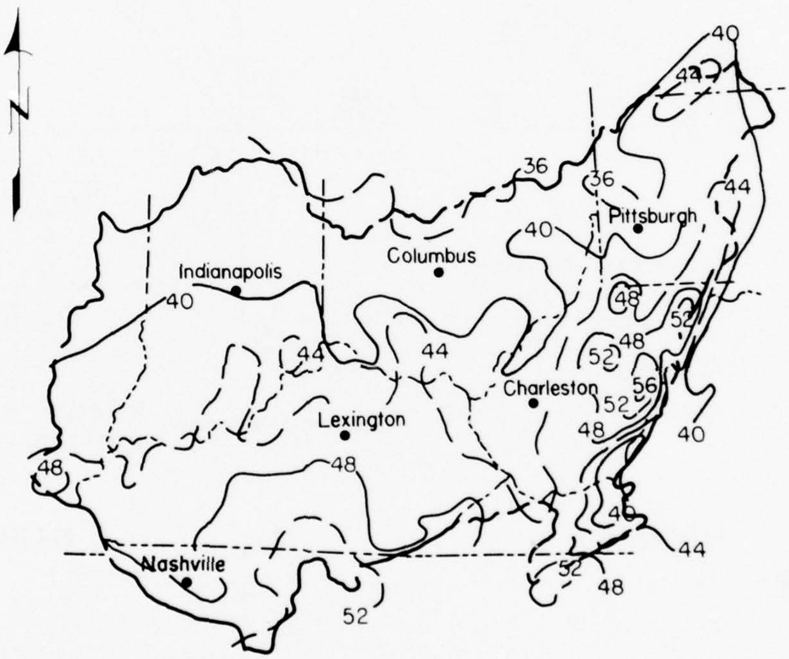


PLATE 4

AVERAGE ANNUAL PRECIPITATION
OHIO RIVER BASIN



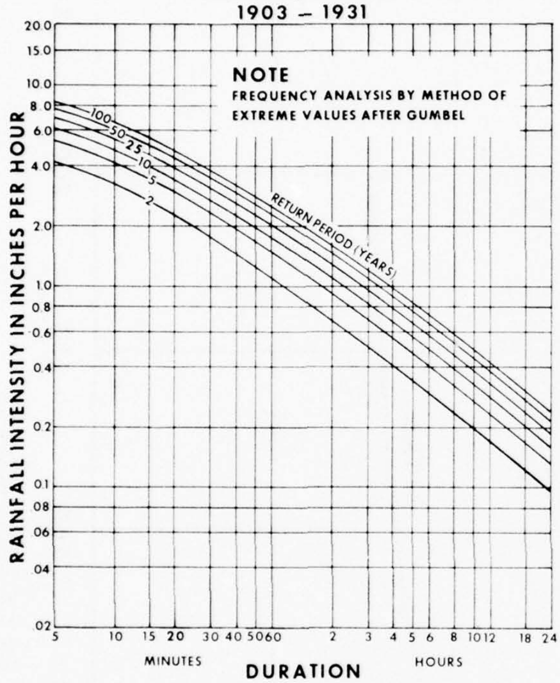
ANNUAL PRECIPITATION (INCHES).

SOURCE: Climatological Maps from National Atlas of United States
Published by U. S. Weather Bureau

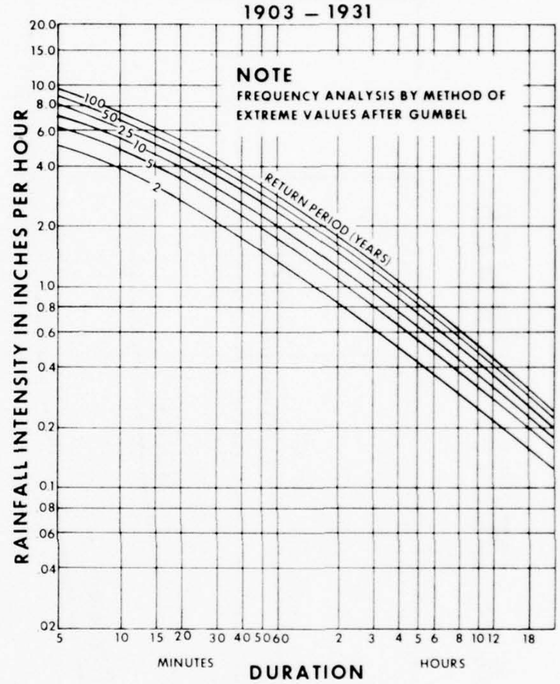
PLATE 5

RAINFALL INTENSITY-DURATION-FREQUENCY CURVES FOR SELECTED OHIO RIVER BASIN STATIONS

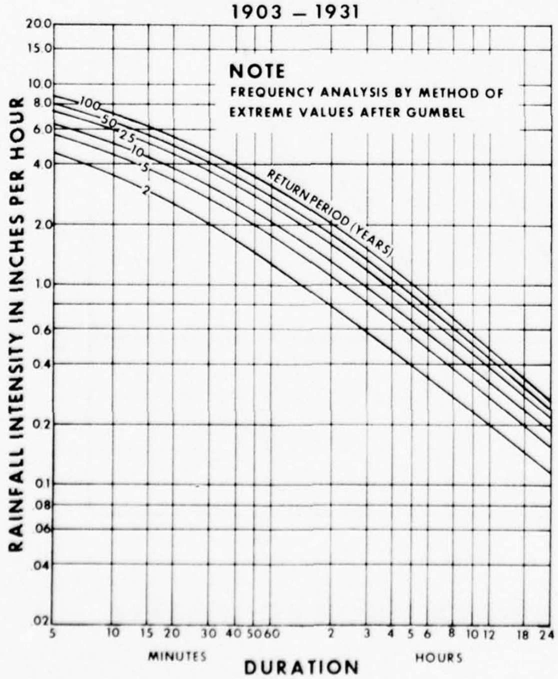
ELKINS, W. VA.
1903 – 1931



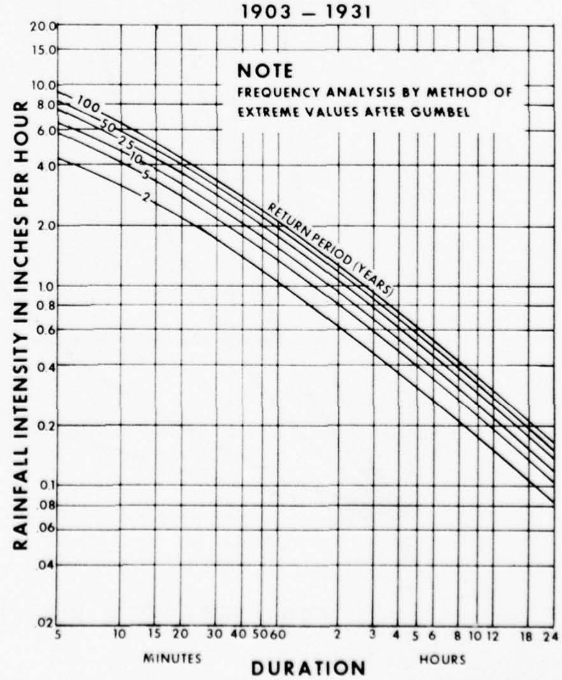
NASHVILLE, TENN.
1903 – 1931



INDIANAPOLIS, IND.
1903 – 1931



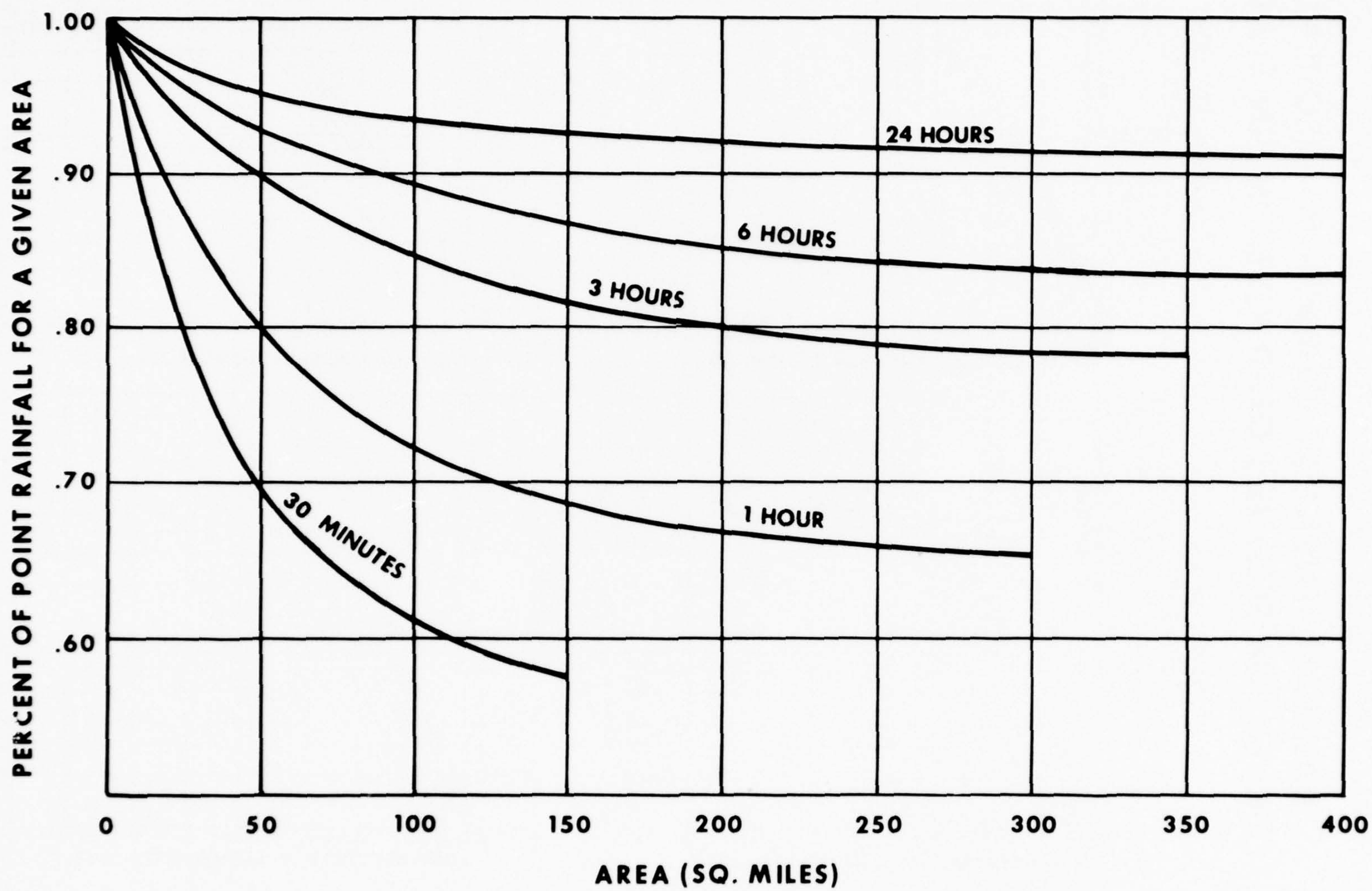
PITTSBURGH, PA.
1903 – 1931



SOURCE: U. S. Weather Bureau & Technical Paper No. 25, Part 1.

PLATE 6

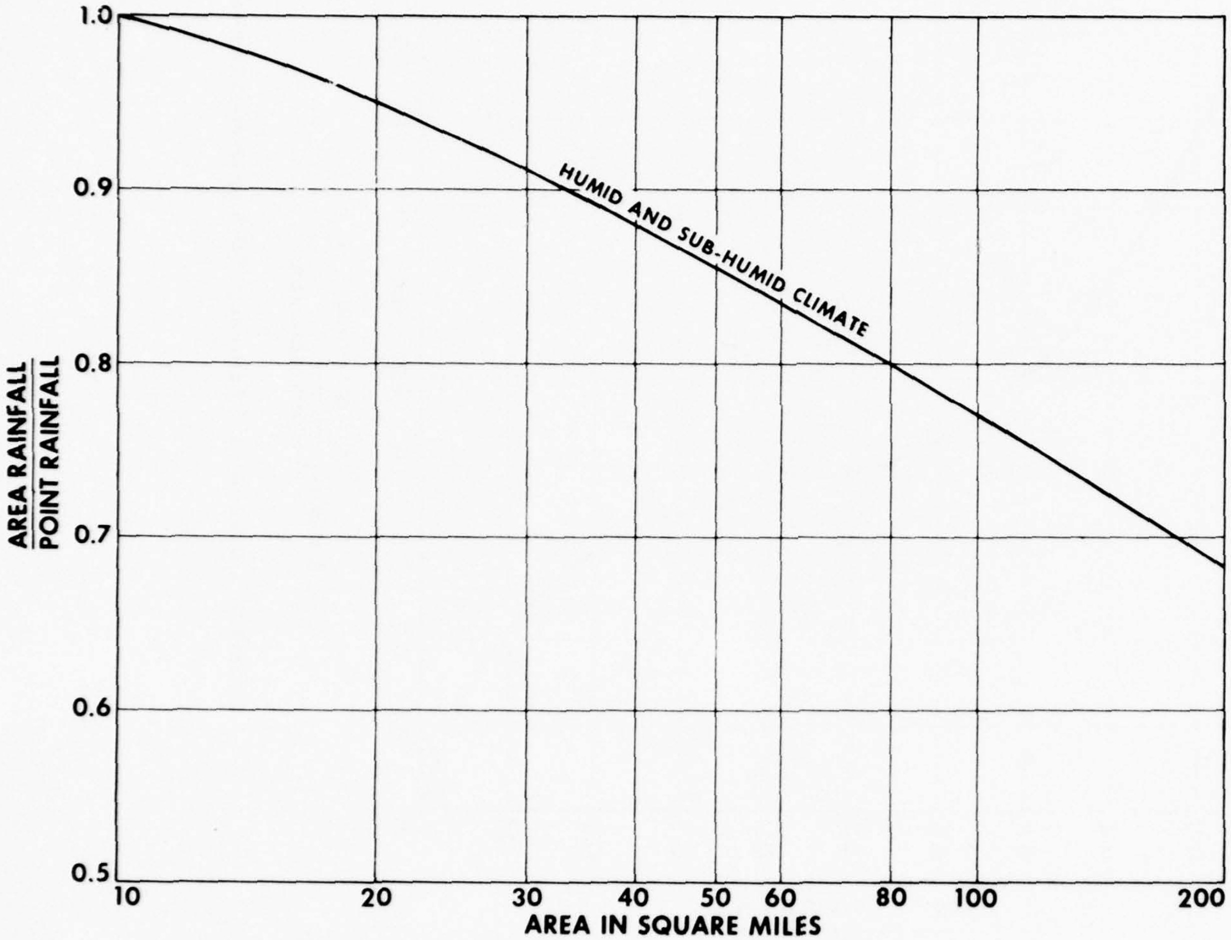
AREA – DEPTH CURVES



Source: U.S. Weather Bureau - Technical No. 25 Part 1

PLATE 7

POINT RAINFALL TO AREA RAINFALL CORRECTION FACTOR

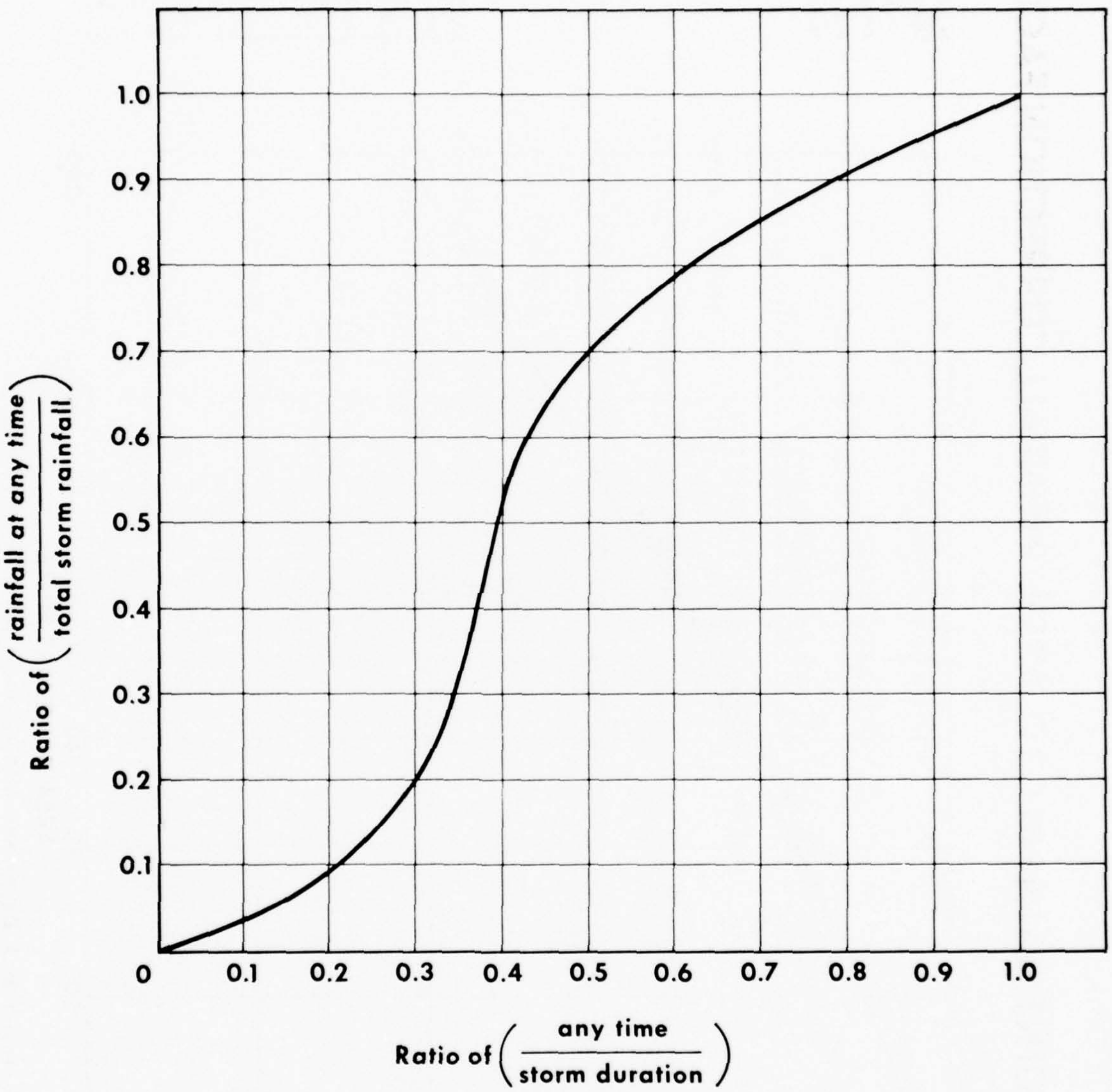


Source: U. S. Department of Agriculture, Soil Conservation Service

NOTE:
Used by Soil Conservation Service for Emergency Spillway Design and Freeboard Storm only.
No correction for areas less than 10 square miles.

AREA SQ. MI.	FACTOR AREA RAINFALL / POINT RAINFALL
0 - 10	1.00
20	.95
30	.91
40	.88
50	.85
100	.77
150	.72
200	.68

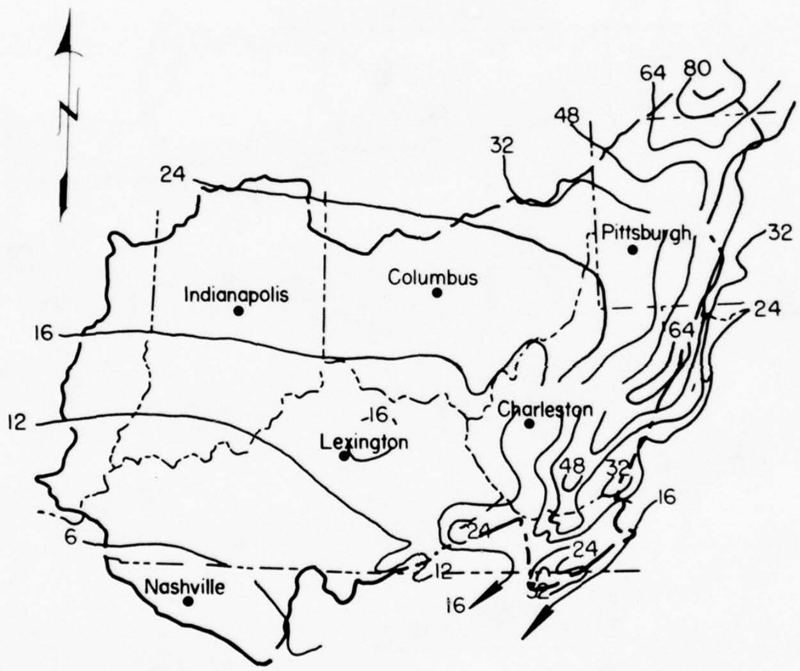
DIMENSIONLESS STORM DISTRIBUTION CURVES



SOURCE: U. S. Department of Agriculture, Soil Conservation Service.

PLATE 9

AVERAGE ANNUAL SNOWFALL
OHIO RIVER BASIN



AVERAGE ANNUAL SNOWFALL (INCHES).

SOURCE: Climatological Maps from National Atlas of United States
Published by U. S. Weather Bureau

PLATE 10

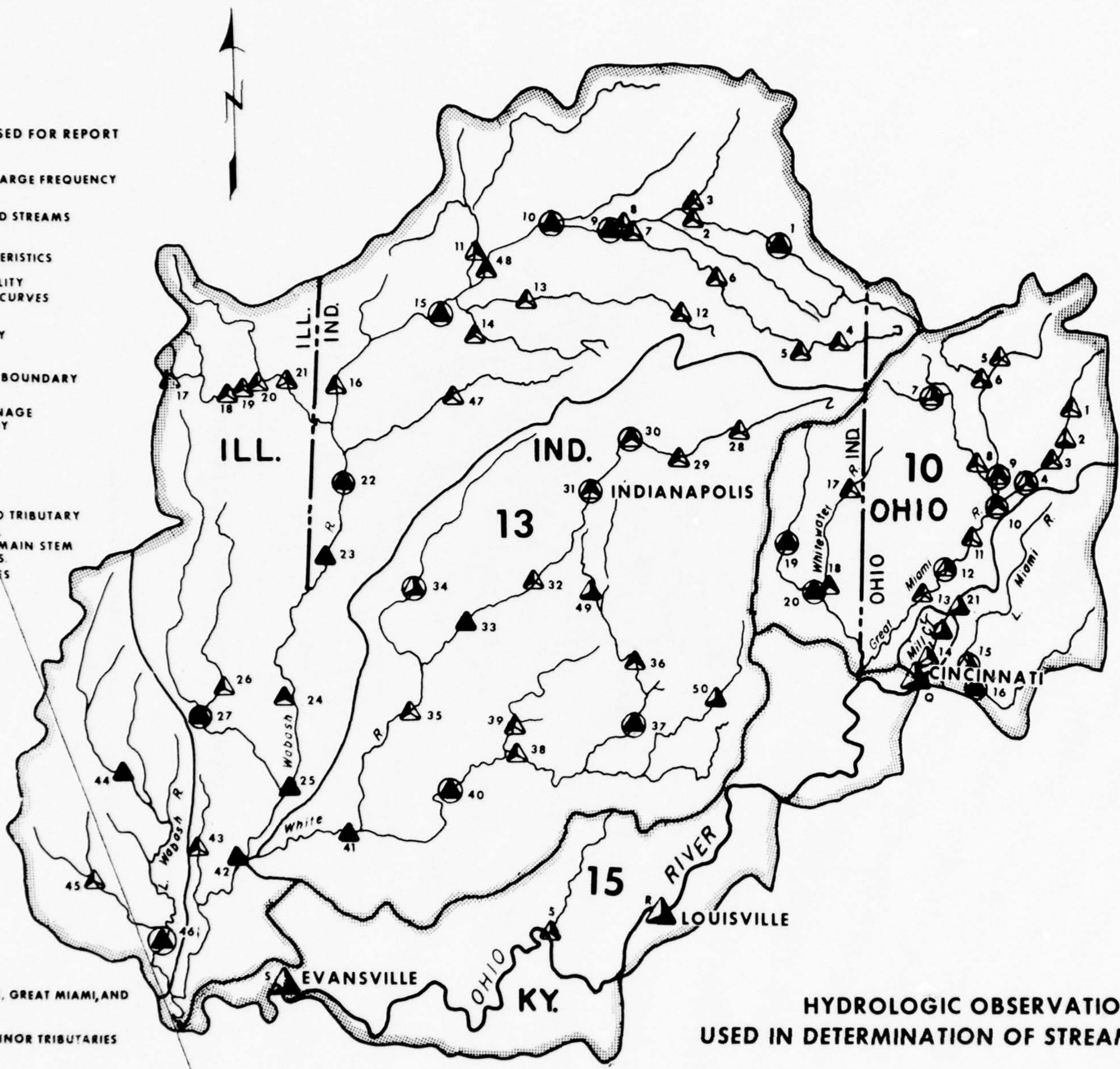
PLATE 11a

GAGING STATIONS USED FOR REPORT

LEGEND:

- LOW FLOW DISCHARGE FREQUENCY
- FLOW OF SELECTED STREAMS
- FLOOD CHARACTERISTICS
- WATER AVAILABILITY FLOW-STORAGE CURVES
- STATE BOUNDARY
- SUB-AREA BASIN BOUNDARY
- TRIBUTARY DRAINAGE BASIN BOUNDARY

NOTE: NUMBERS REFER TO TRIBUTARY GAGING STATION. LETTERS REFER TO MAIN STEM GAGING STATIONS. AS LISTED IN TABLES 9 11 & 12



JB-AREA BASINS:

10-LITTLE MIAMI, MILL CREEK, GREAT MIAMI, AND WHITEWATER RIVER
13-WABASH RIVER
15-OHIO MAIN STEM AND MINOR TRIBUTARIES

HYDROLOGIC OBSERVATION STATIONS
USED IN DETERMINATION OF STREAM CHARACTERISTICS

HYDROLOGIC OBSERVATION STATIONS USED IN DETERMINATION OF STREAM CHARACTERISTICS

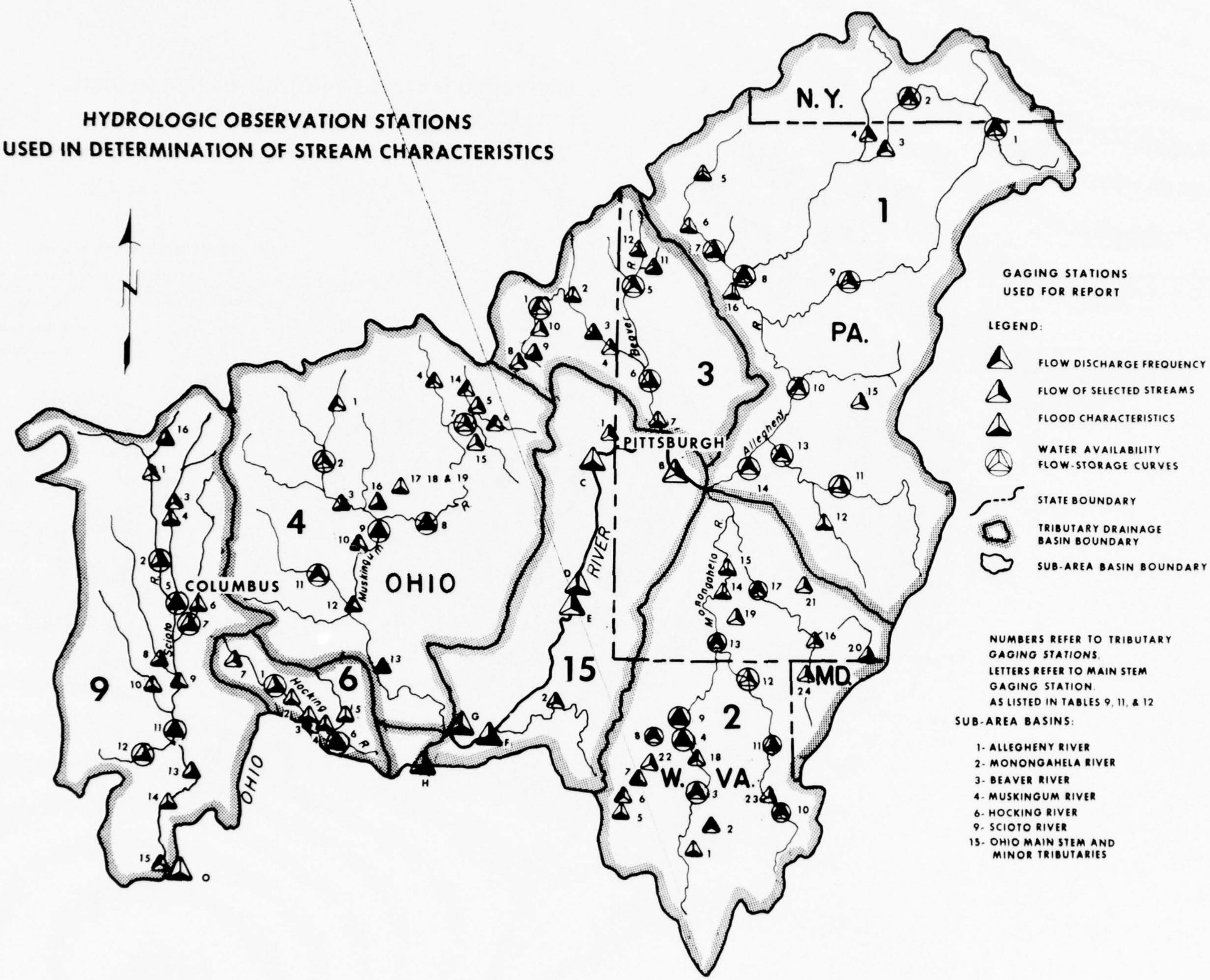
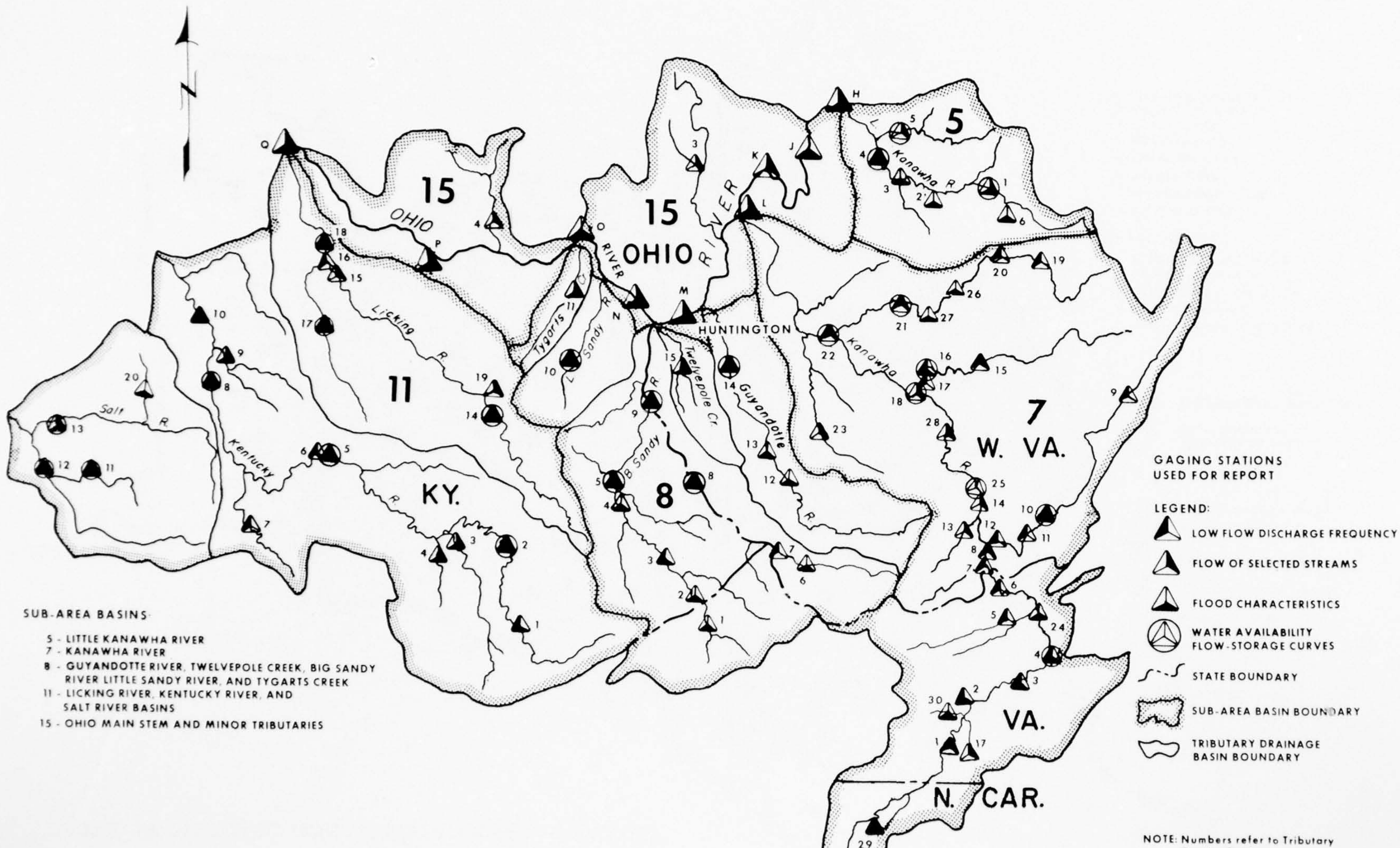


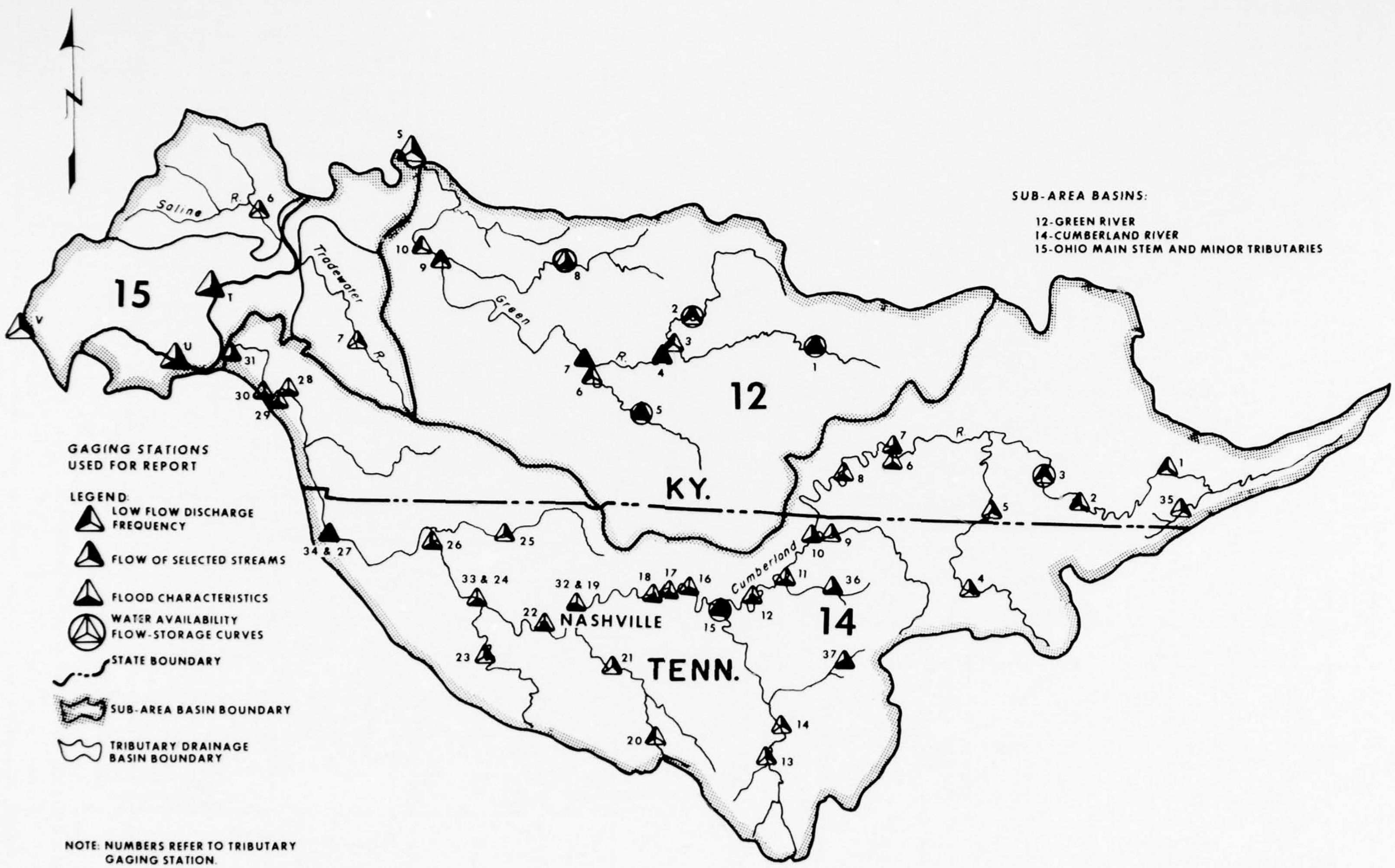
PLATE 11b

PLATE 11c



NOTE: Numbers refer to Tributary Gaging Station.
Letters refer to Main Stem Gaging Stations.
As listed in tables 9 11 & 12

HYDROLOGIC OBSERVATION STATIONS
USED IN DETERMINATION OF STREAM CHARACTERISTICS

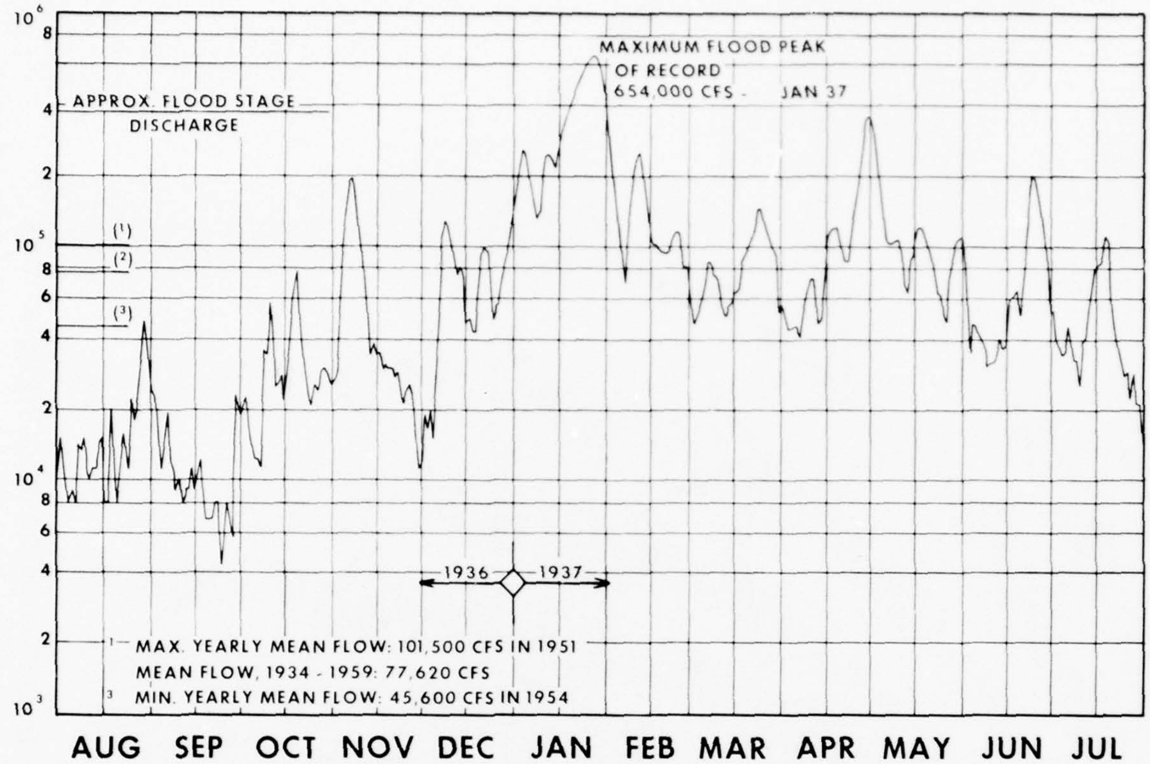


HYDROLOGIC OBSERVATION STATIONS USED IN DETERMINATION OF STREAM CHARACTERISTICS

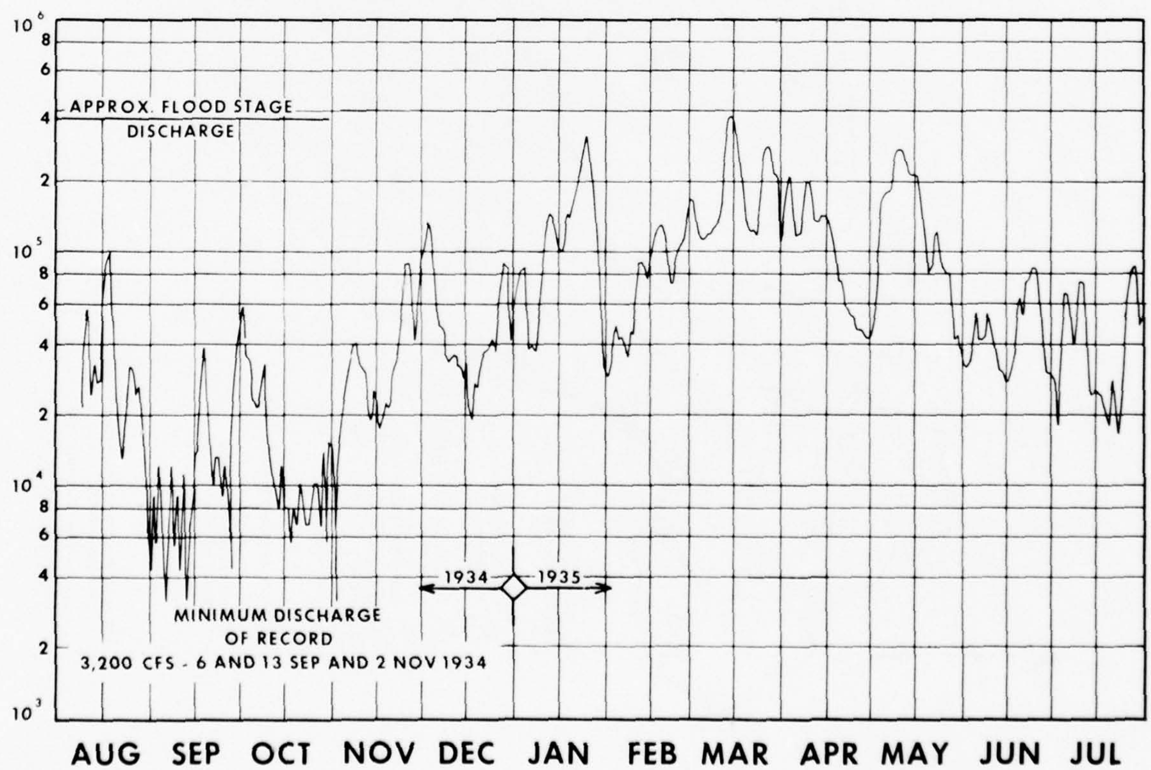
PLATE 11d

HYDROGRAPHS FOR THE OHIO RIVER AT HUNTINGTON, W.VA. FOR YEARS OF EXTREME DISCHARGES

AVERAGE DAILY DISCHARGE - CFS
(IN LOGARITHMIC SCALE)



12 - MONTH PERIOD WITH PEAK DISCHARGE
AUGUST 1936 - JULY 1937

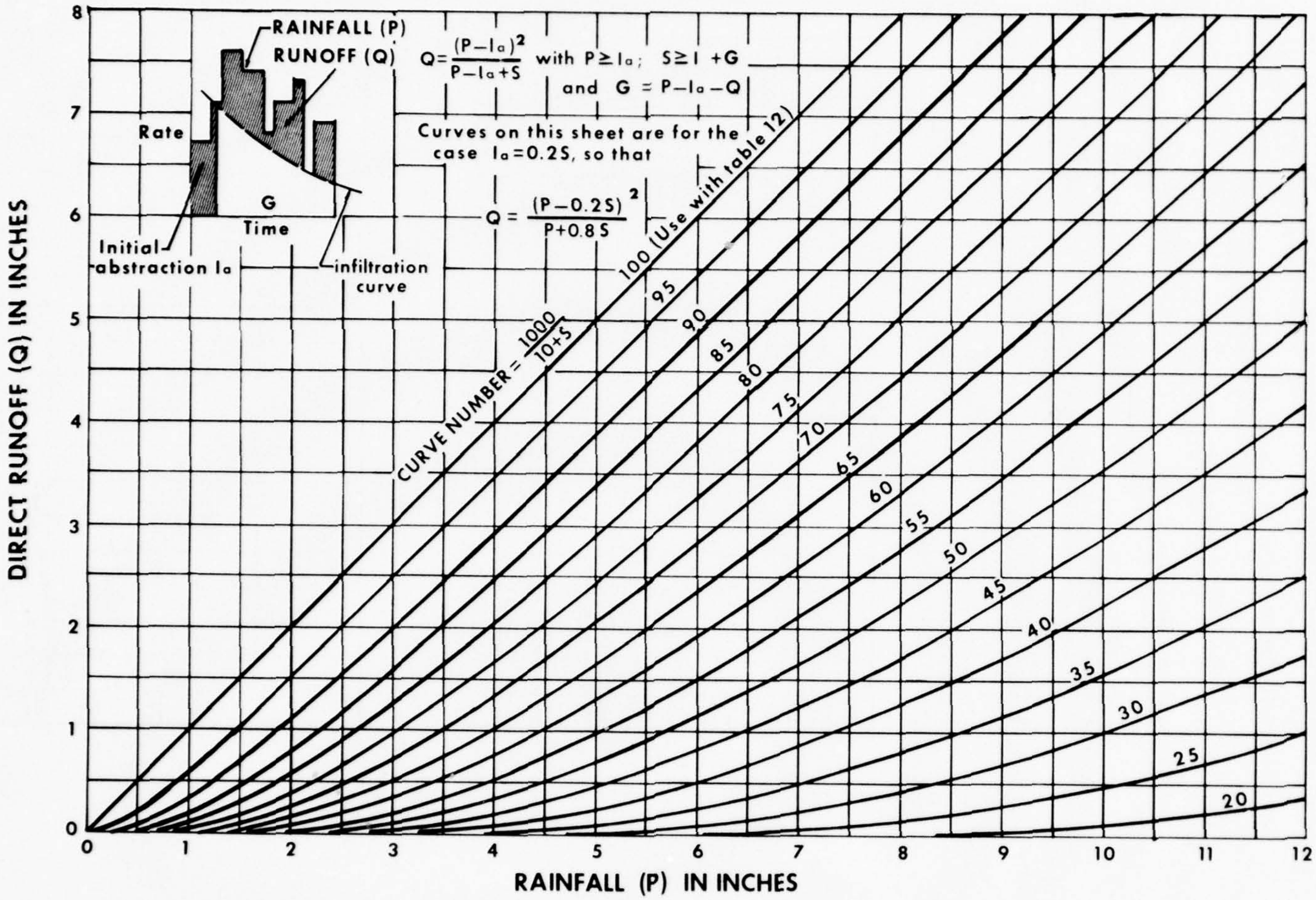


12 - MONTH PERIOD WITH MINIMUM DISCHARGE
AUGUST 1934 - JULY 1935

PLATE 12

NOMOGRAPH FOR SOLUTION OF RUNOFF EQUATION FROM SMALL WATERSHEDS

SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$ FOR A GIVEN STORM WHERE Q = 0 to 8 inches, P = 0 to 12 inches



Source: U. S. Department of Agriculture, Soil Conservation Service

MONTHLY DISTRIBUTION OF FLOOD FLOWS BASED ON HIGHEST MEAN DAILY FLOWS ABOVE BASES INDICATED FOR SELECTED OHIO RIVER BASIN STATIONS

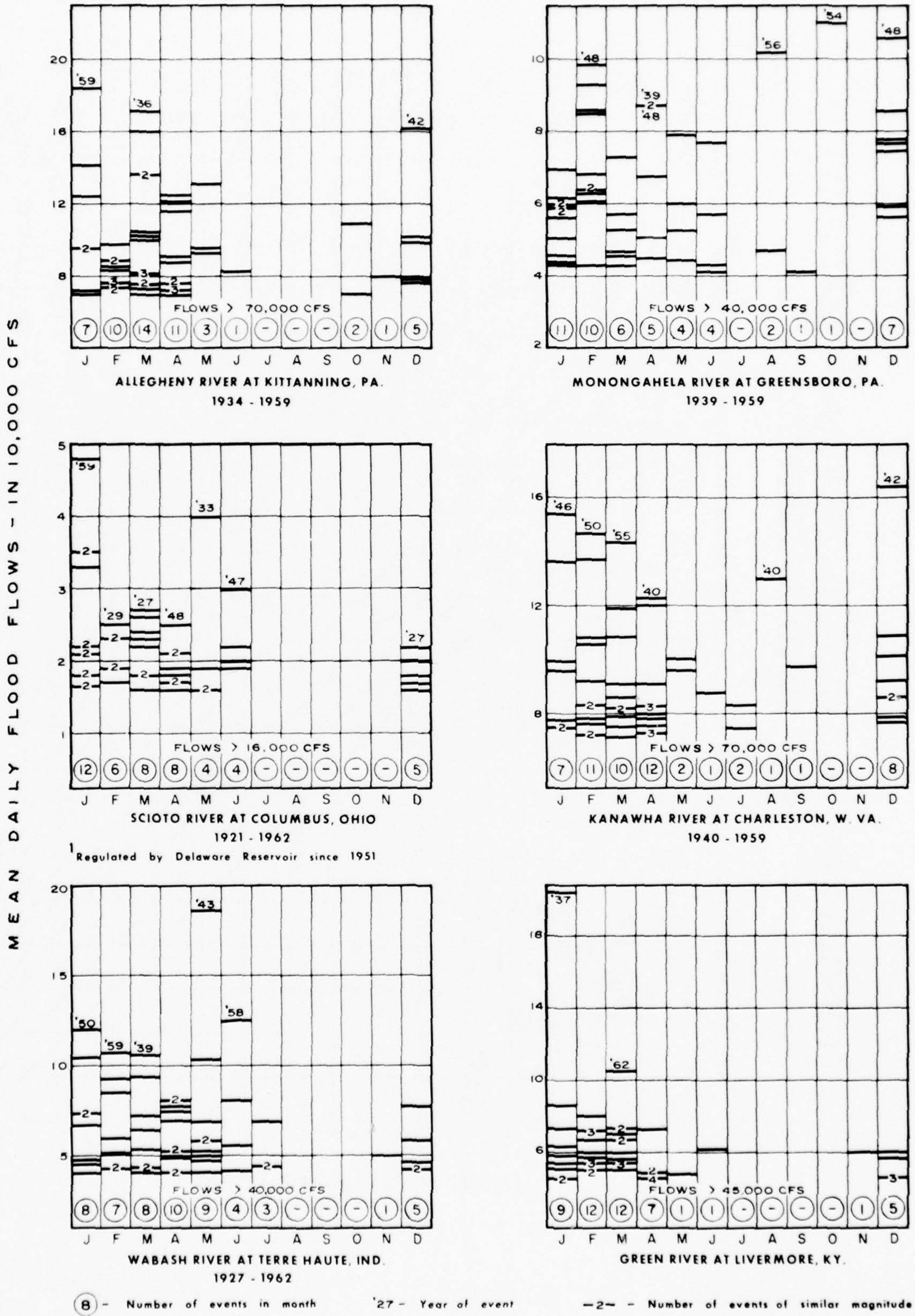
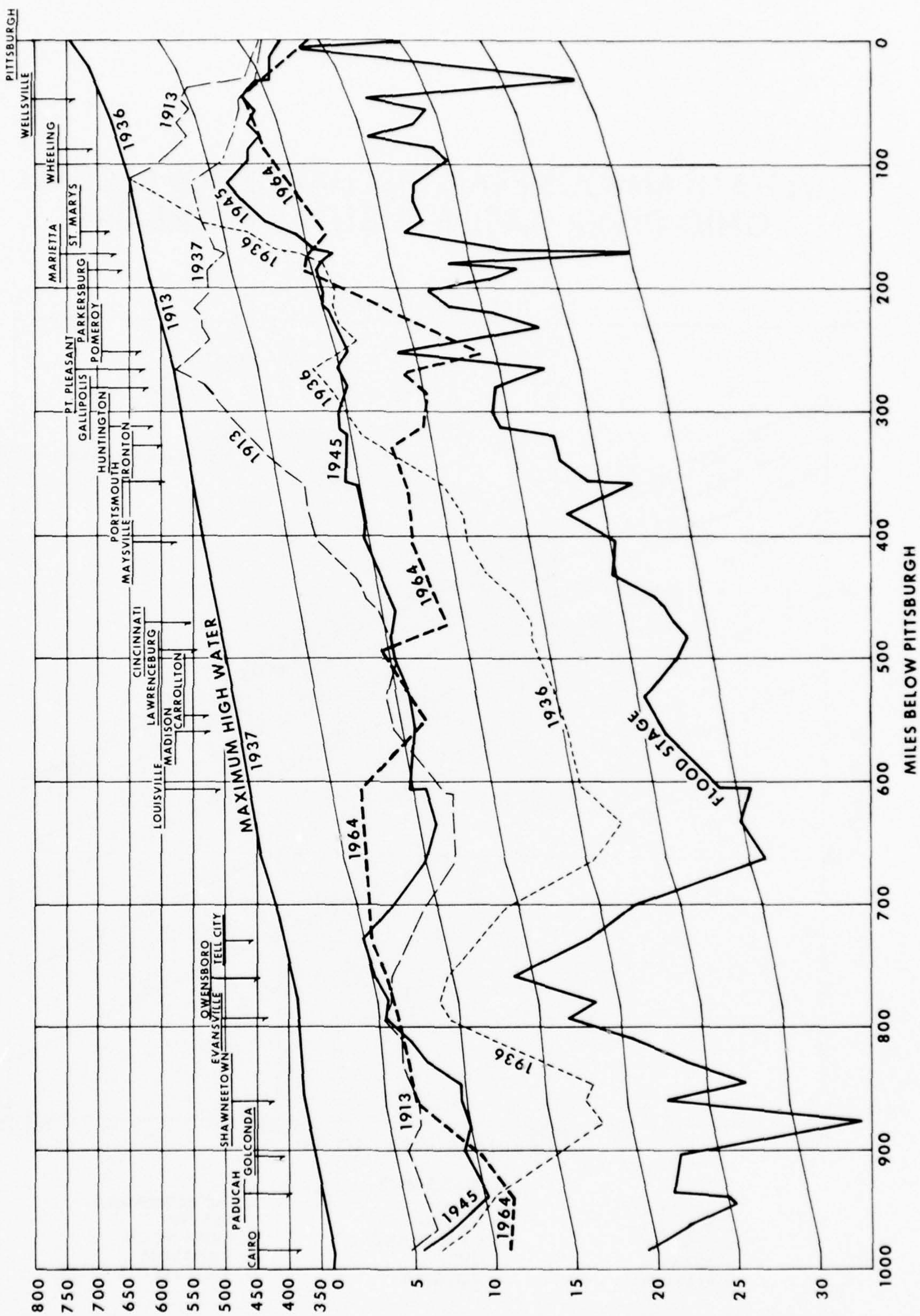
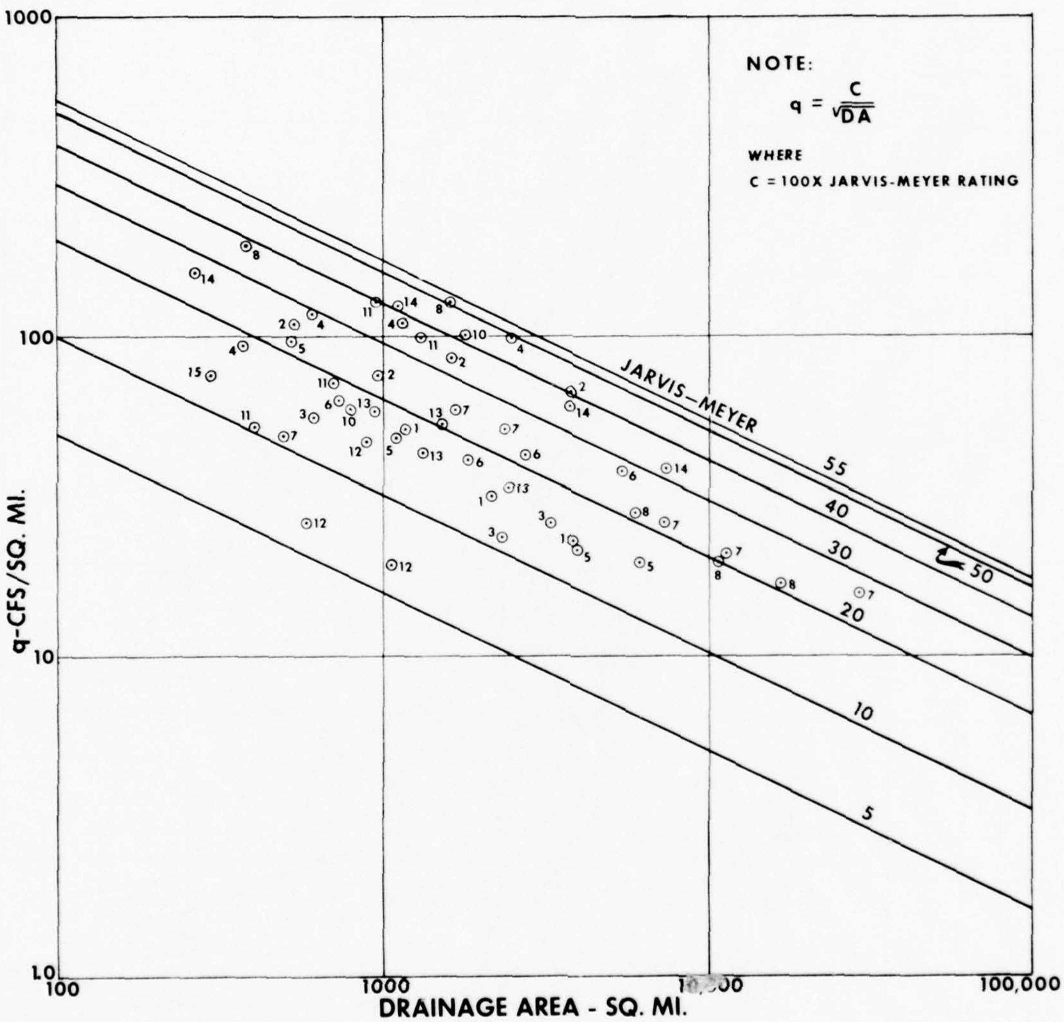


PLATE 14

RELATIVE FLOOD STAGE PROFILES - OHIO RIVER



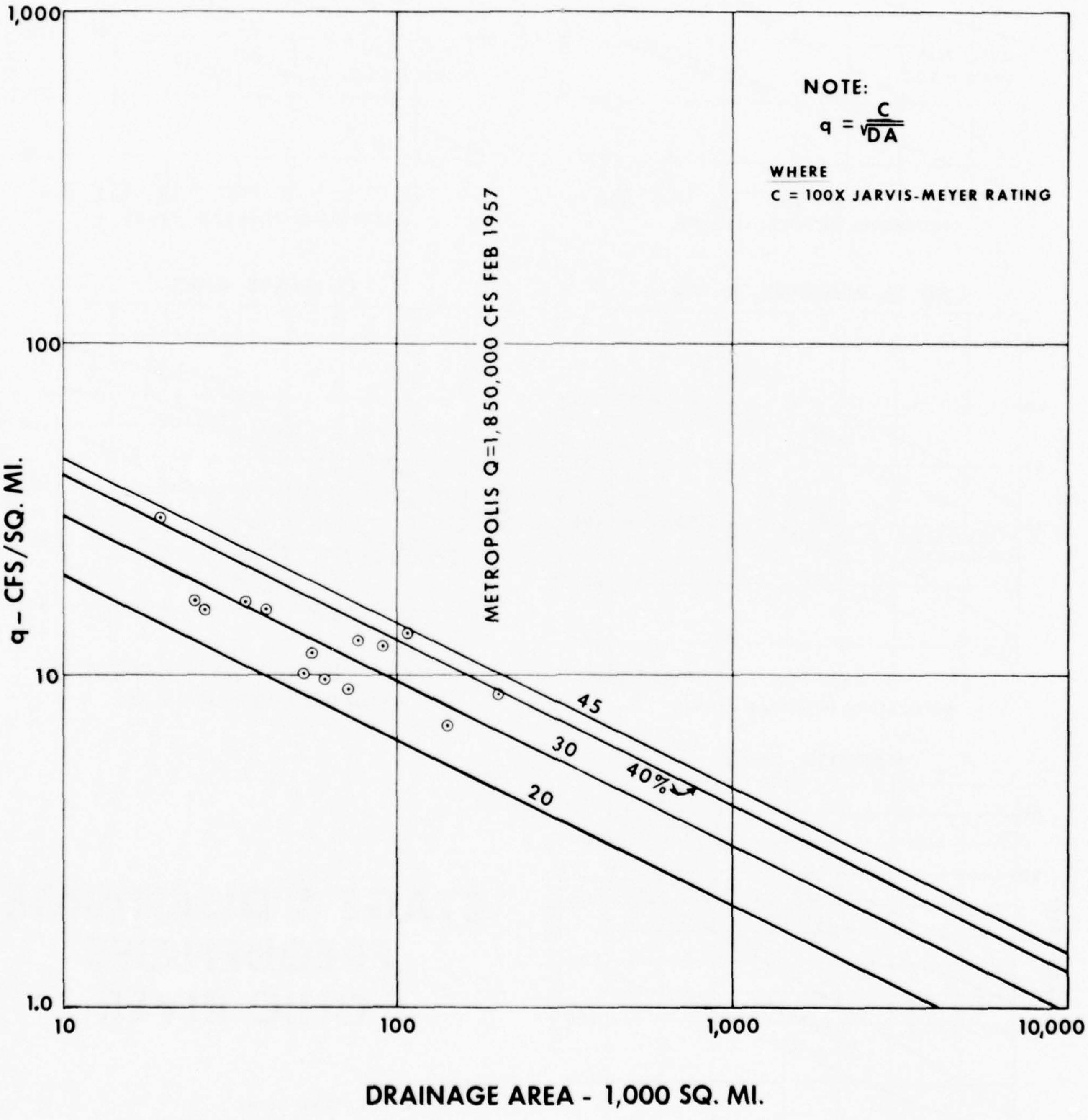
INSTANTANEOUS PEAK DISCHARGES OF RECORD OHIO RIVER BASIN TRIBUTARY STREAMS



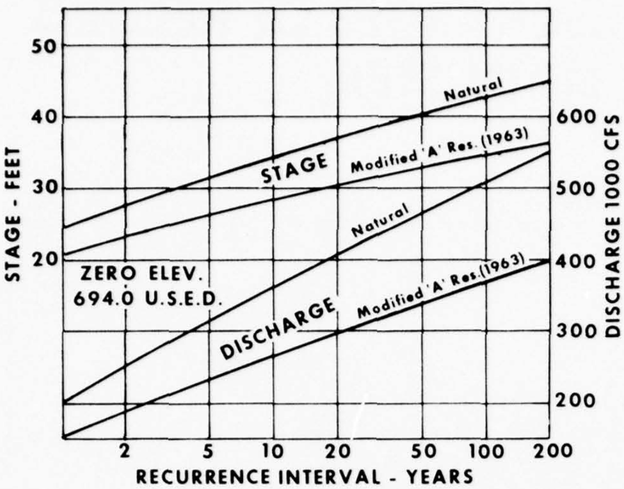
SUB—BASINS

1 BIG SANDY
2 SCIOTO
3 LICKING
4 MIAMI
5 KENTUCKY
6 GREEN
7 WABASH
8 CUMBERLAND
9 OHIO
10 ALLEGHENY
11 MONONGAHELA
12 BEAVER
13 MUSKINGUM
14 KANAWHA
15 TWELVEPOLE CREEK

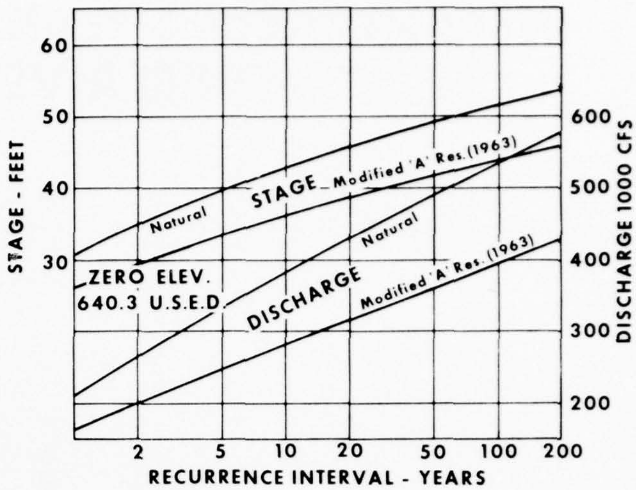
INSTANTANEOUS PEAK DISCHARGES OF RECORD
OHIO RIVER MAIN STEM



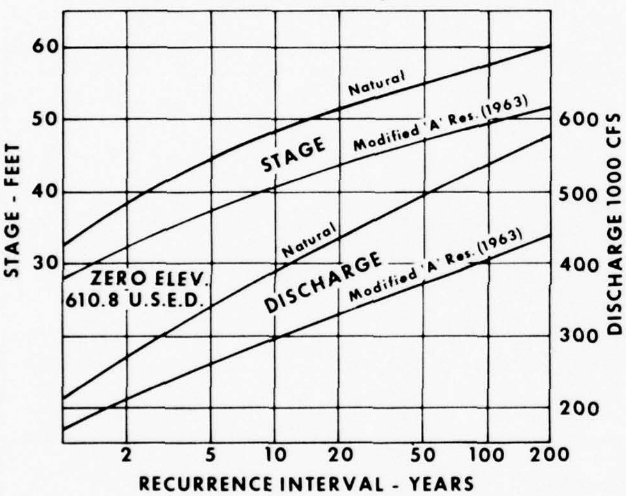
PITTSBURGH, PA.



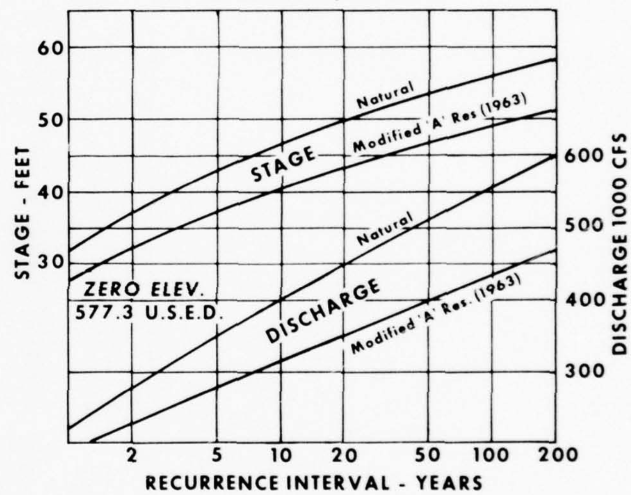
L &D 8, WELLSVILLE, OHIO



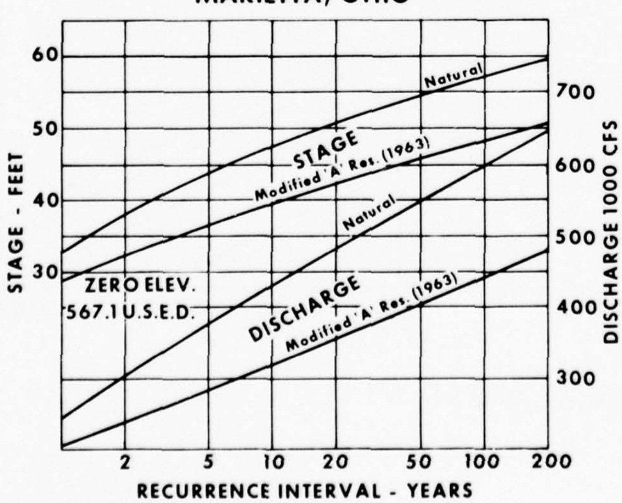
L &D 12, WHEELING, W. VA.



ST. MARYS, OHIO



MARIETTA, OHIO

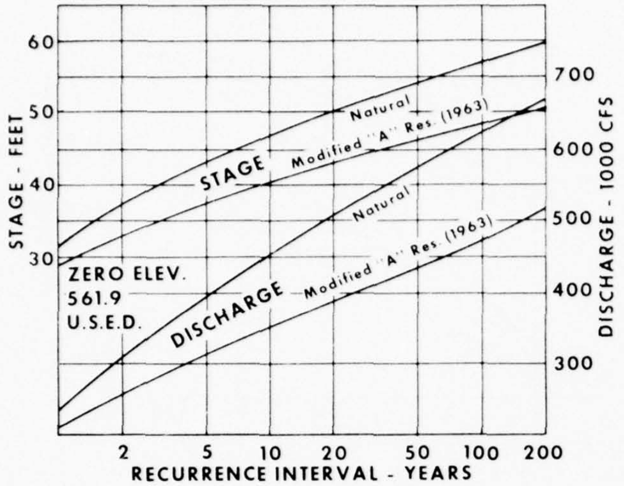


STAGE & DISCHARGE FREQUENCIES OHIO RIVER

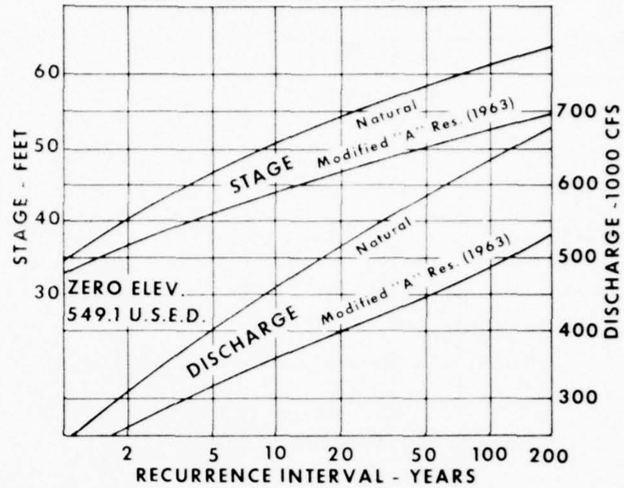
NOTE:

'A' Res. (1963)-Corps of Engineers Reservoirs constructed, under construction and in preconstruction planning as of July 1963.

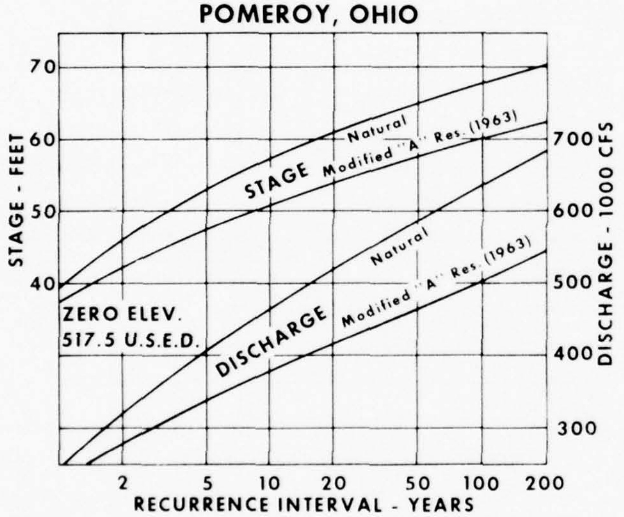
PARKERSBURG, W. VA.



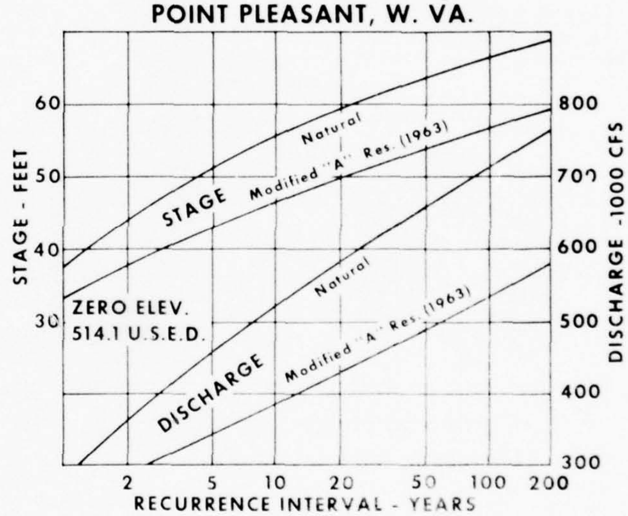
L&D 20, BELLEVILLE, OHIO



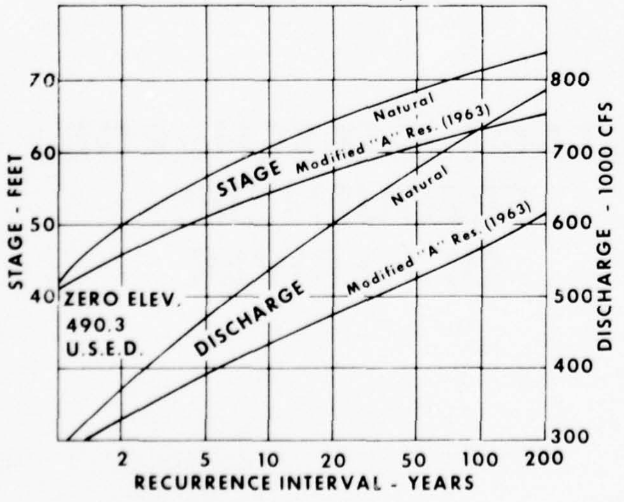
POMEROY, OHIO



POINT PLEASANT, W. VA.



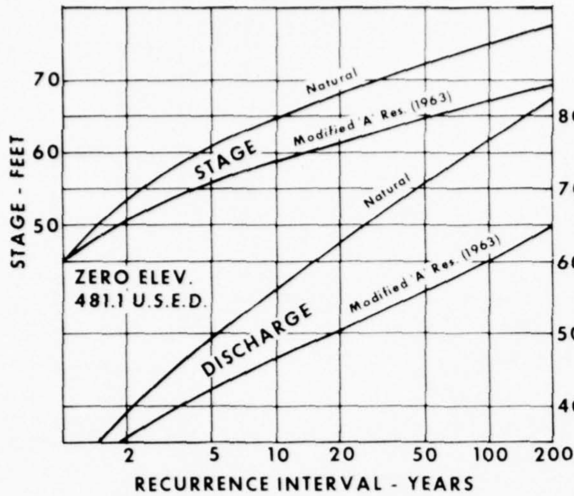
L&D 28, HUNTINGTON, W. VA.



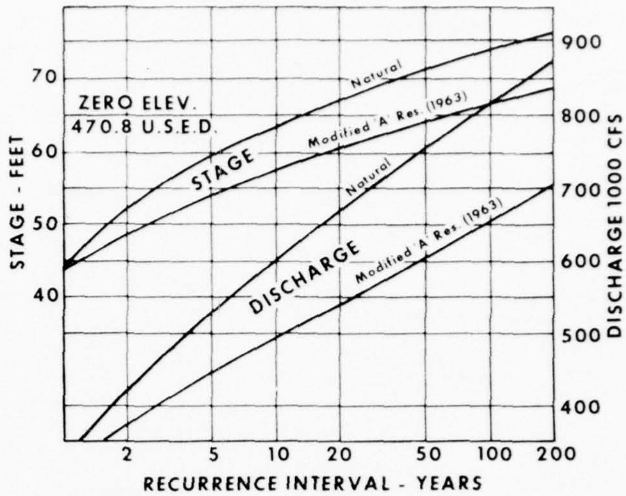
STAGE & DISCHARGE FREQUENCIES
OHIO RIVER

PLATE 18b

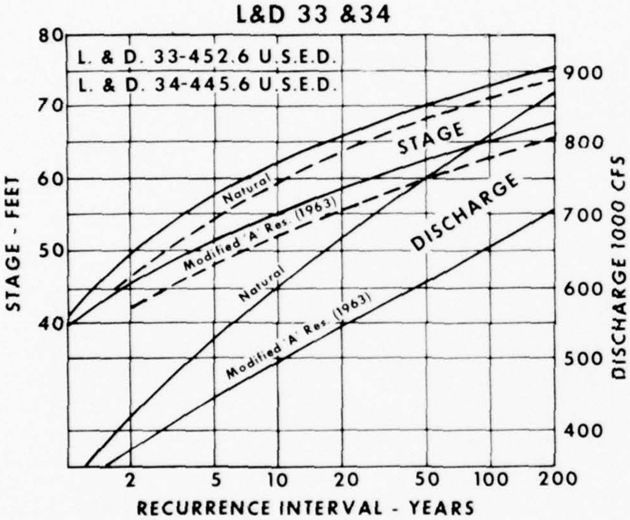
L&D 29, ASHLAND, KY.



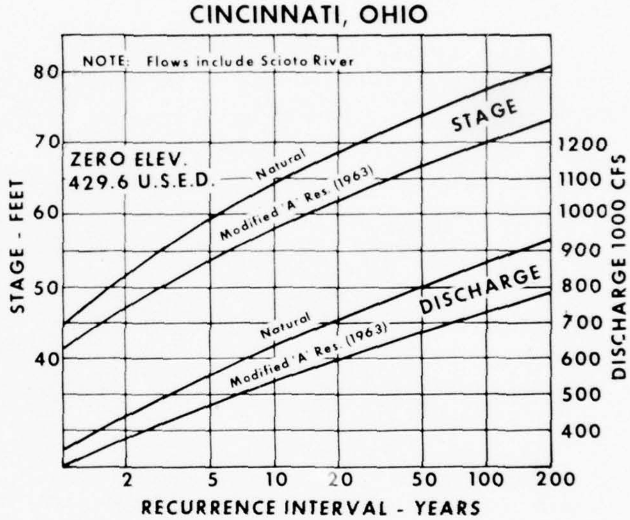
PORTSMOUTH, OHIO



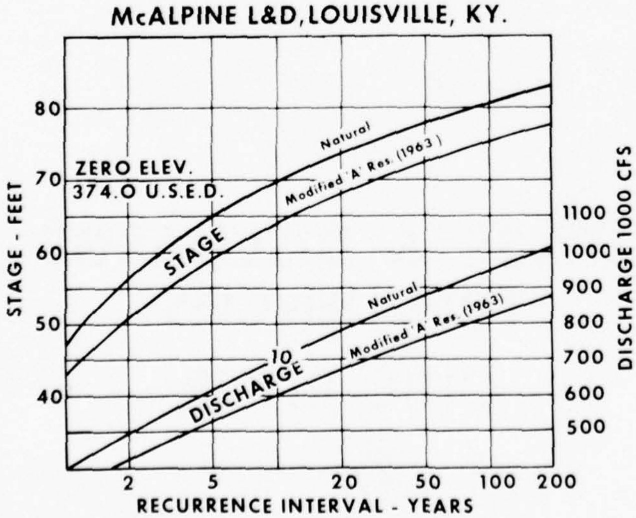
L&D 33 &34



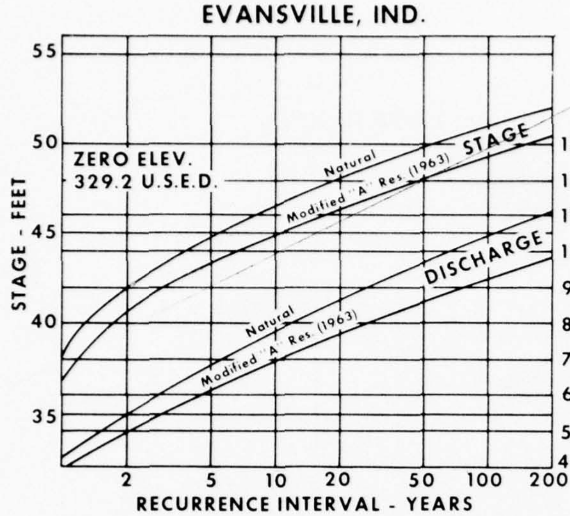
CINCINNATI, OHIO

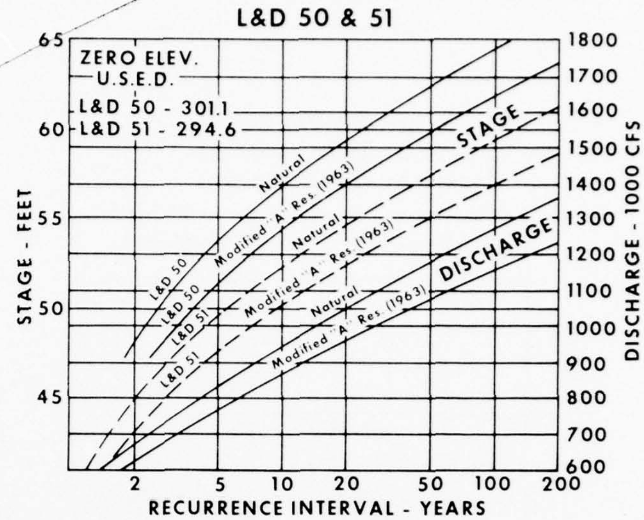


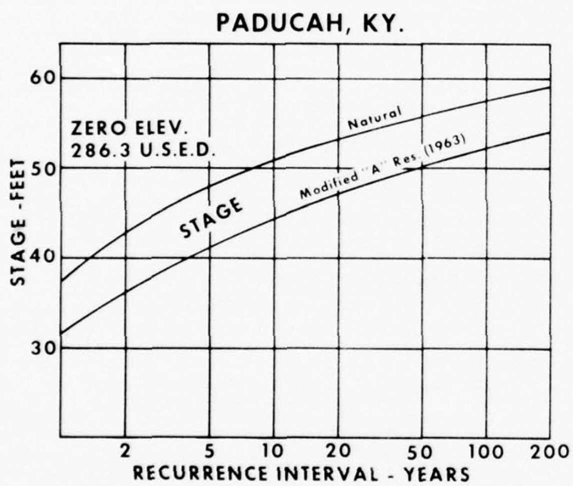
McALPINE L&D, LOUISVILLE, KY.

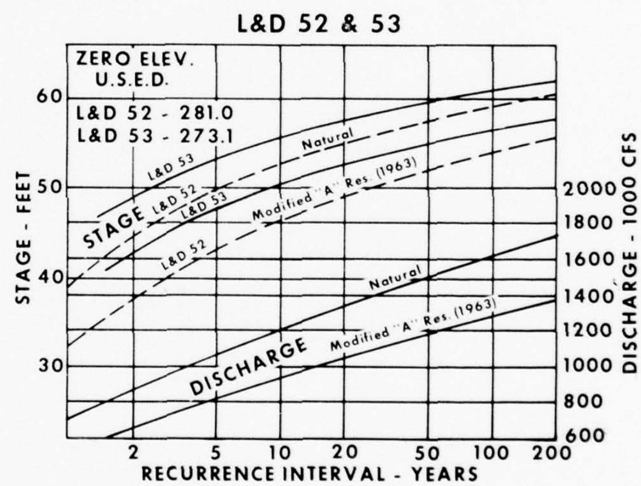


STAGE & DISCHARGE FREQUENCIES OHIO RIVER





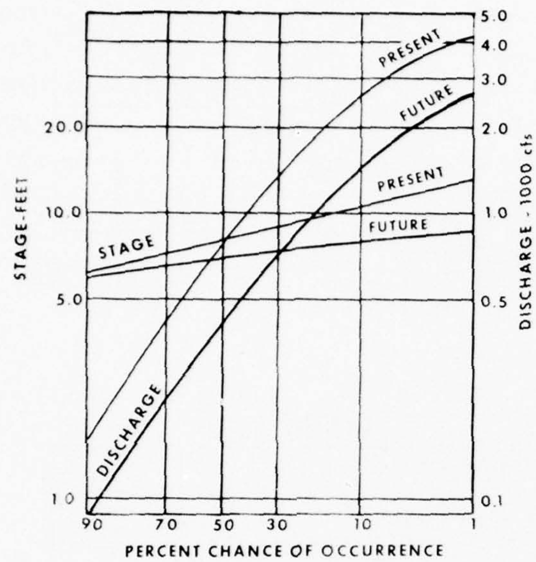




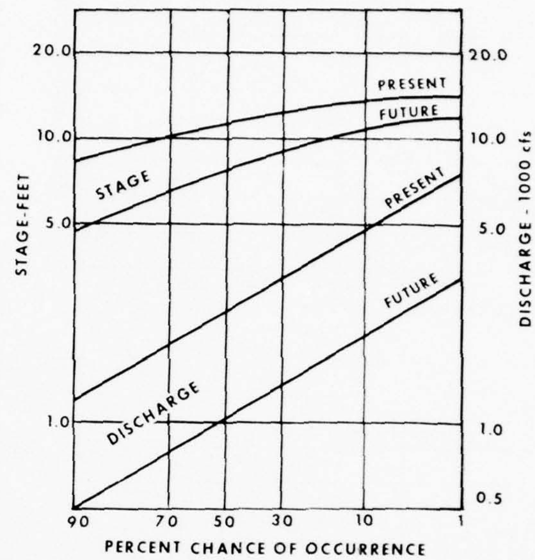
STAGE & DISCHARGE FREQUENCIES OHIO RIVER

STAGE AND DISCHARGE FREQUENCIES
FOR SELECTED UPSTREAM WATERSHED AREAS IN THE OHIO RIVER BASIN

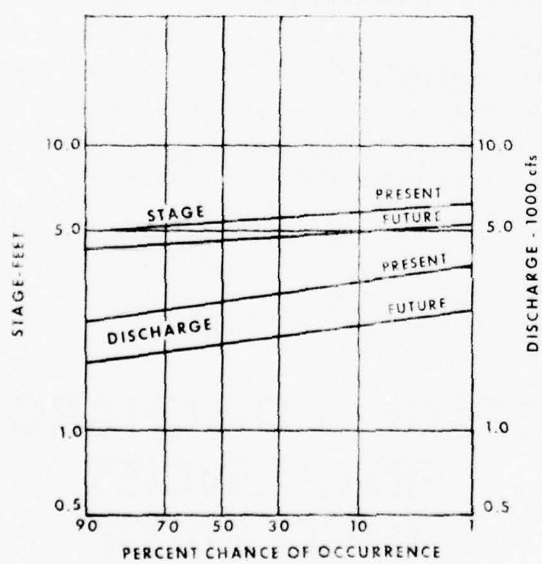
HOCKING RIVER BASIN
MARGARET CREEK WATERSHED
DRAINAGE AREA-33.4 SQ. MILES



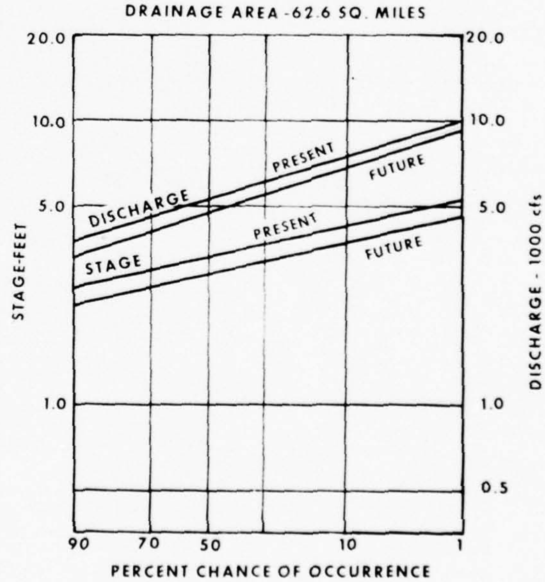
WABASH RIVER BASIN
LITTLE RACOON WATER WATERSHED
DRAINAGE AREA -133 SQ. MILES



SALT RIVER BASIN
PLUM CREEK WATERSHED
DRAINAGE AREA-19.1 SQ. MILES



CUMBERLAND RIVER BASIN
WILSON SPRING CREEK WATERSHED
DRAINAGE AREA -62.6 SQ. MILES



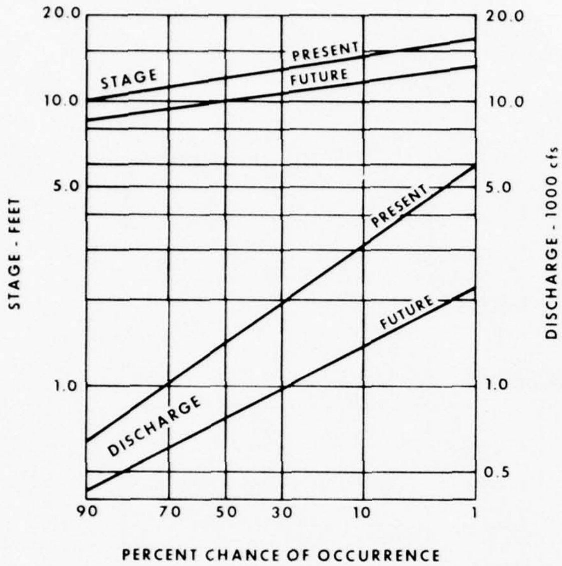
SOURCE: U.S. Department of Agriculture, Soil Conservation Service
NOTE: FUTURE ASSUMES SOIL CONSERVATION SERVICE PROJECT COMPLETED

STAGE AND DISCHARGE FREQUENCY
FOR SELECTED UPSTREAM WATERSHED AREAS IN THE OHIO RIVER BASIN

ALLEGHENY RIVER BASIN

SAND CREEK WATERSHED

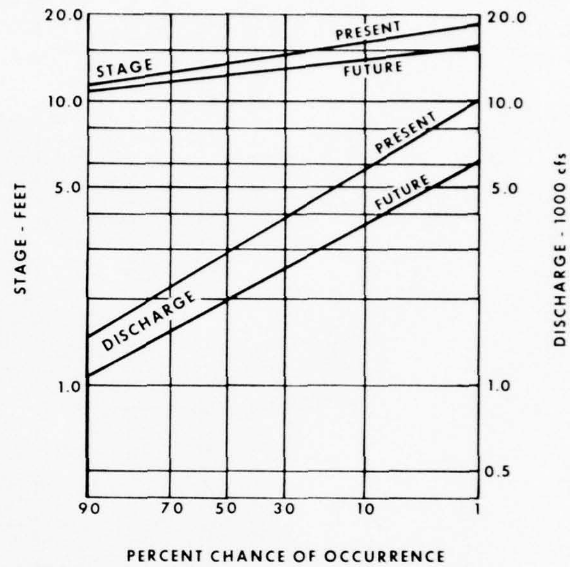
DRAINAGE AREA - 57.3 SQ. MILES



BEAVER RIVER BASIN

LITTLE SHENANGO RIVER WATERSHED

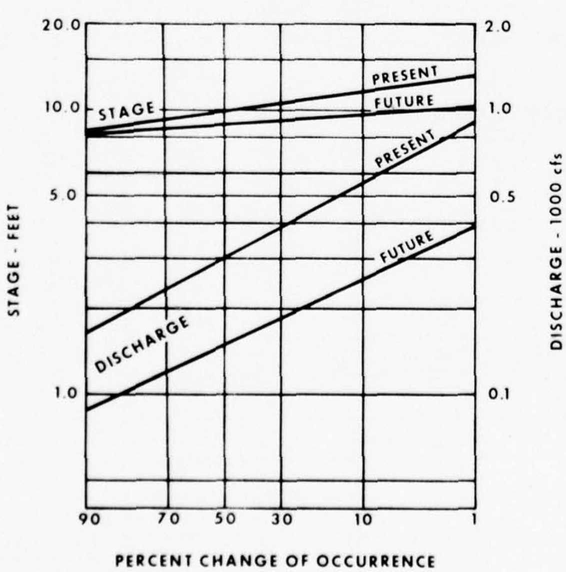
DRAINAGE AREA - 104 SQ. MILES



BEAVER RIVER BASIN

SAUL RUN WATERSHED

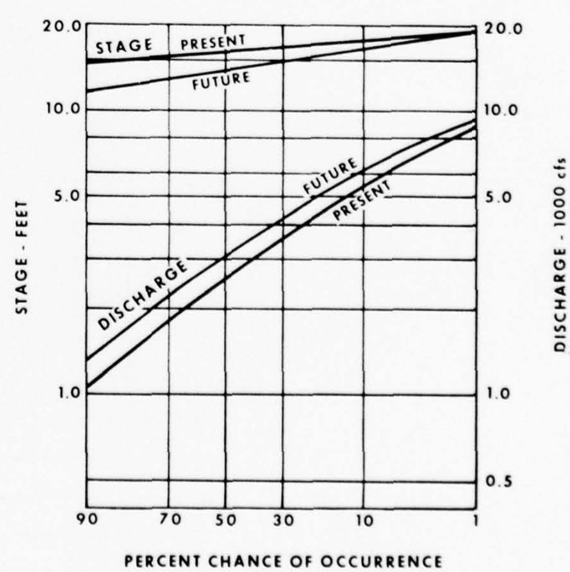
DRAINAGE AREA - 1.73 SQ. MILES



MUSKINGUM RIVER BASIN

CHIPPEWA CREEK WATERSHED

DRAINAGE AREA - 146 SQ. MILES

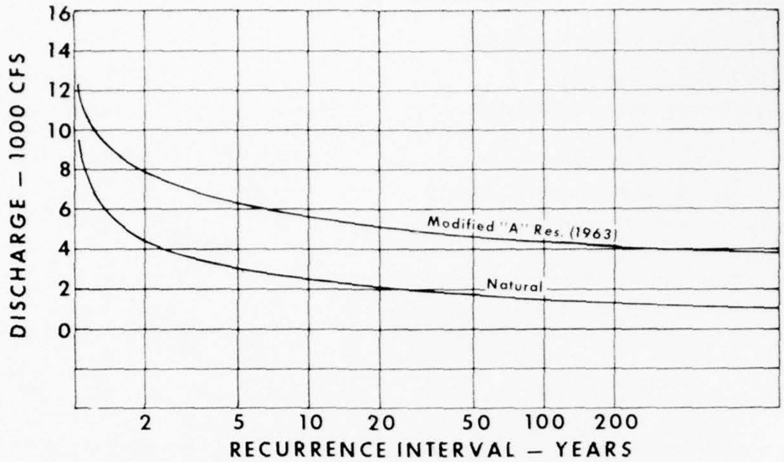


SOURCE: U. S. Department of Agriculture, Soil Conservation Service

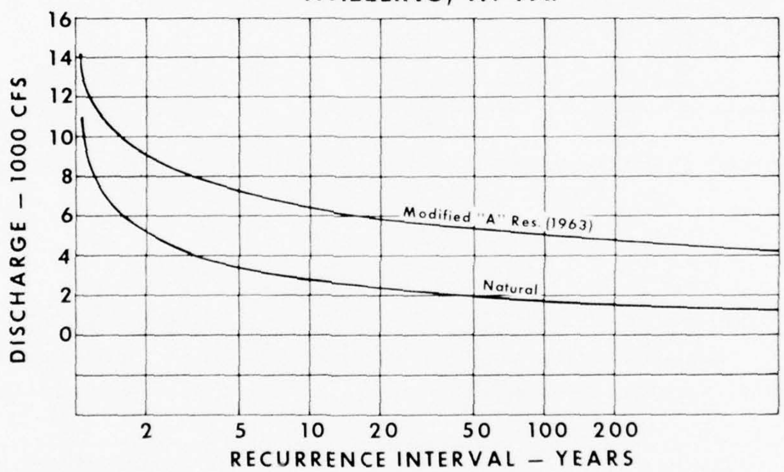
NOTE: FUTURE ASSUMES SOIL CONSERVATION SERVICE PROJECT COMPLETED

30 DAY AVERAGE
LOW FLOW FREQUENCIES - OHIO RIVER

PITTSBURGH, PA.



WHEELING, W. VA.



PARKERSBURG, W. VA.

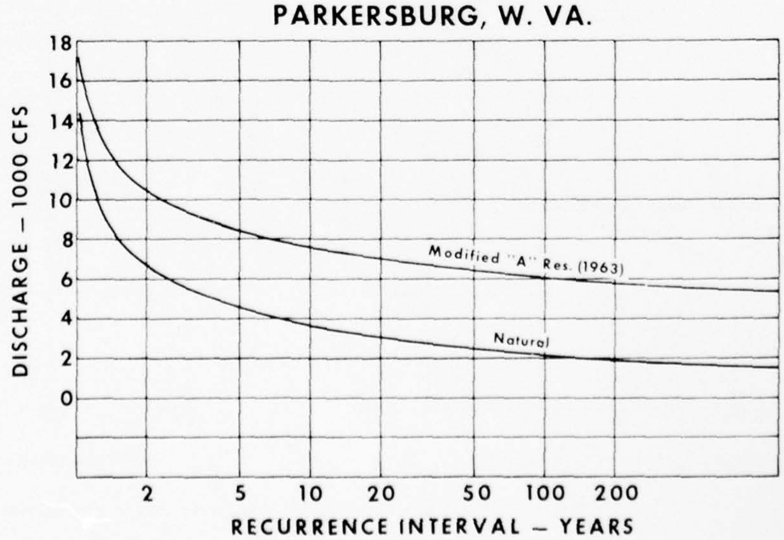
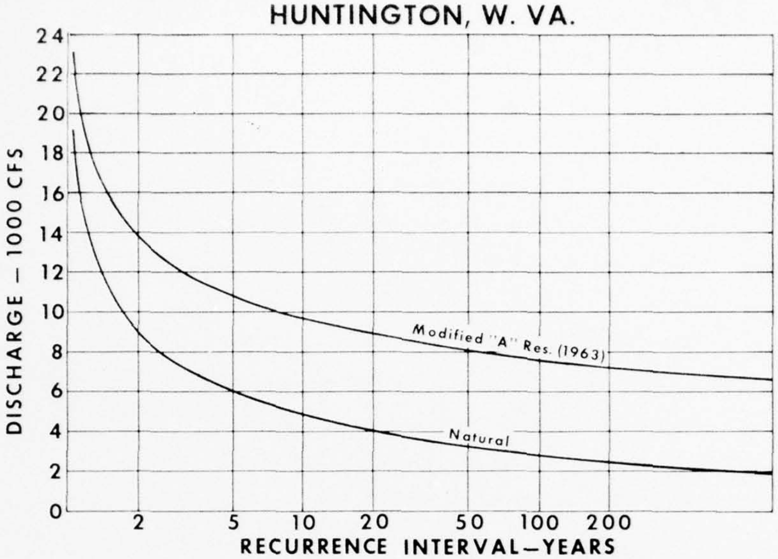


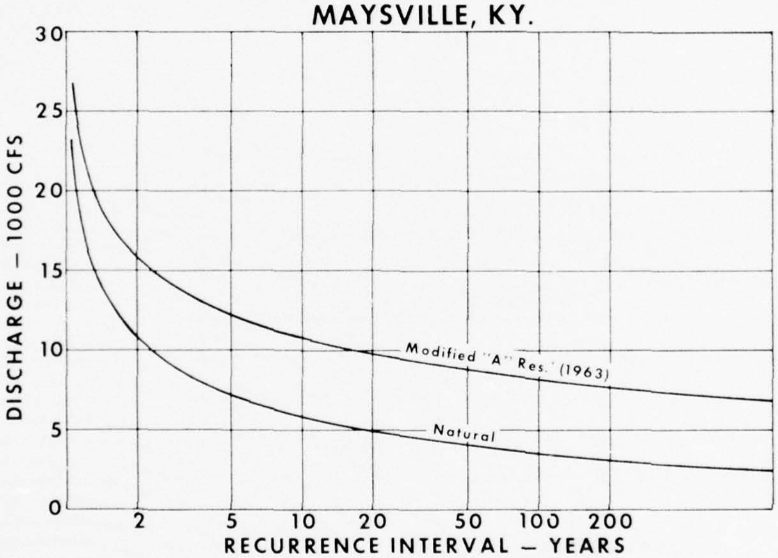
PLATE 20a

30 DAY AVERAGE
LOW FLOW FREQUENCIES - OHIO RIVER

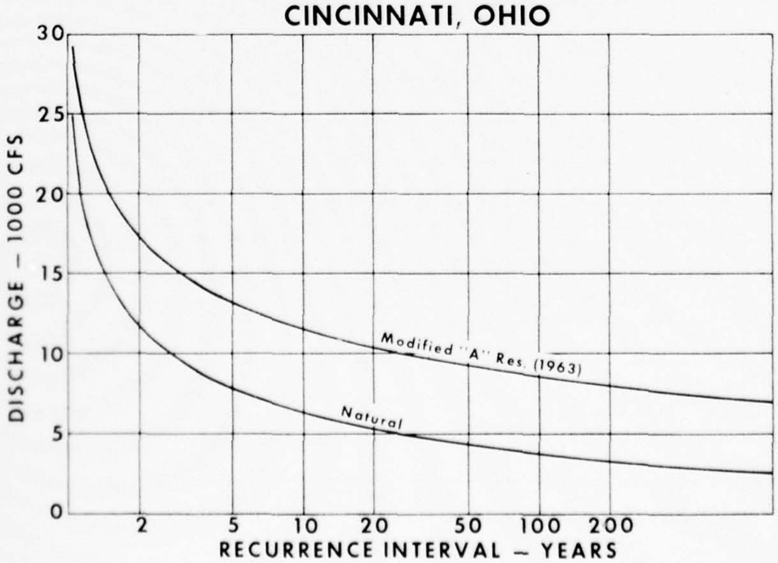
HUNTINGTON, W. VA.



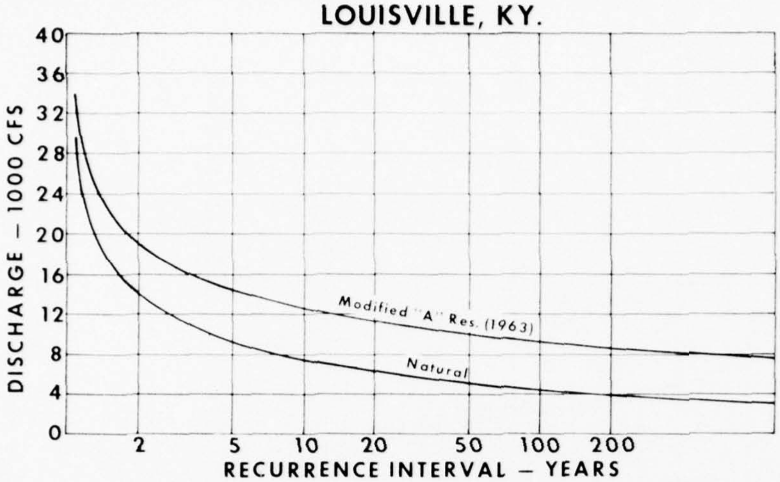
MAYSVILLE, KY.

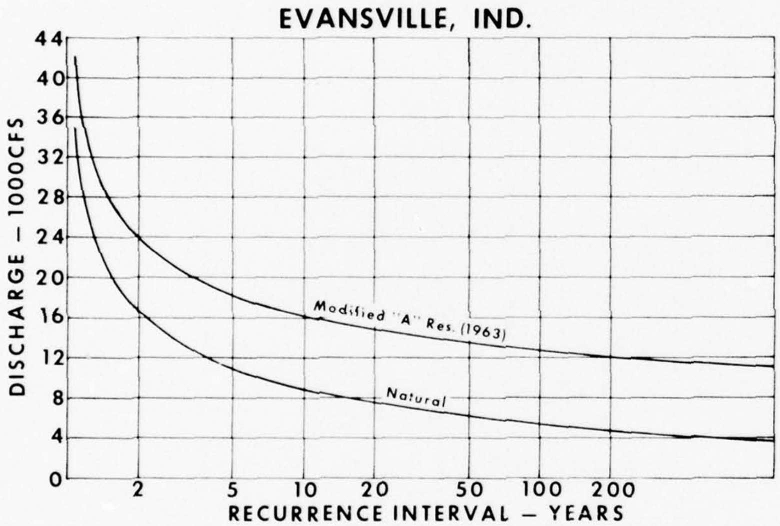


CINCINNATI, OHIO



30 DAY AVERAGE
LOW FLOW FREQUENCIES - OHIO RIVER





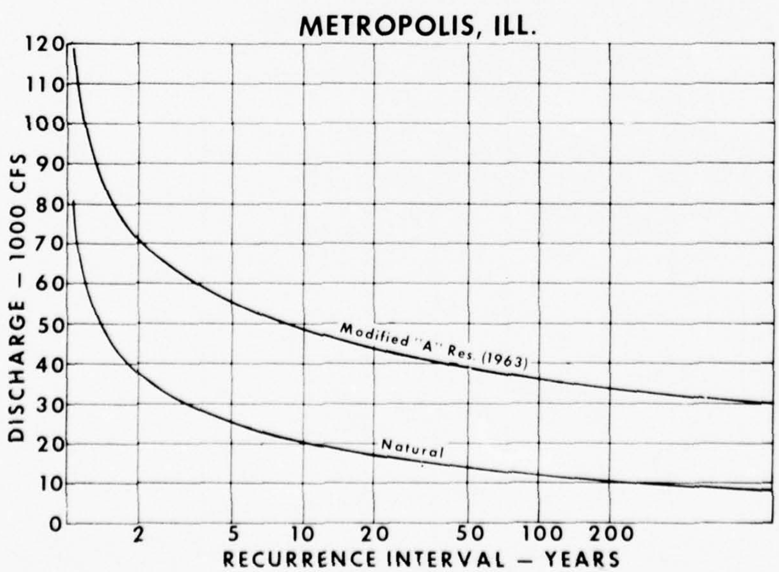
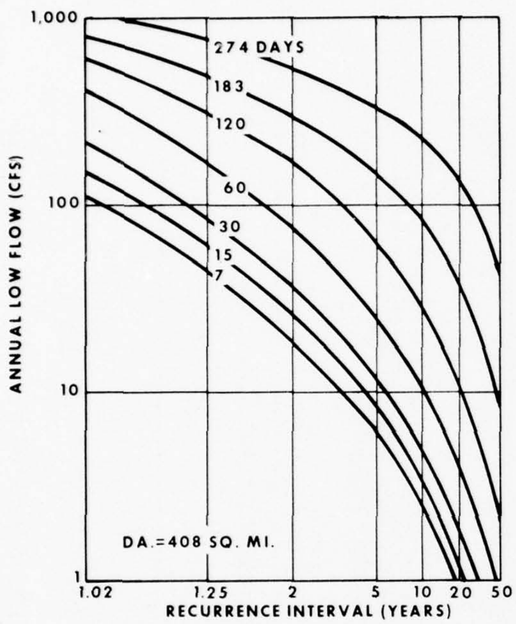


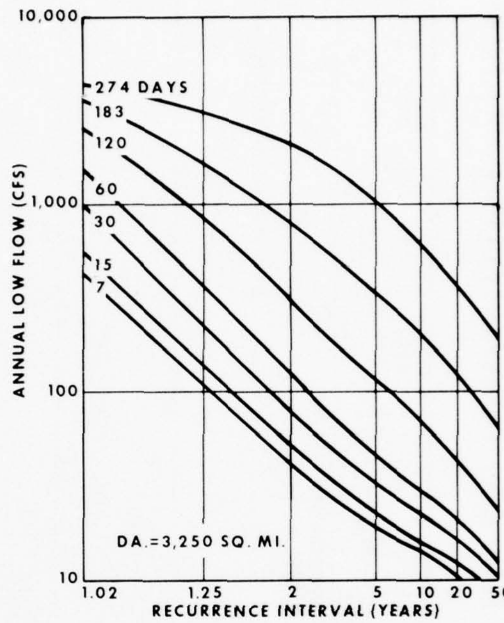
PLATE 20c

LOW FLOW FREQUENCY CURVES FOR SELECTED OHIO RIVER BASIN STATIONS

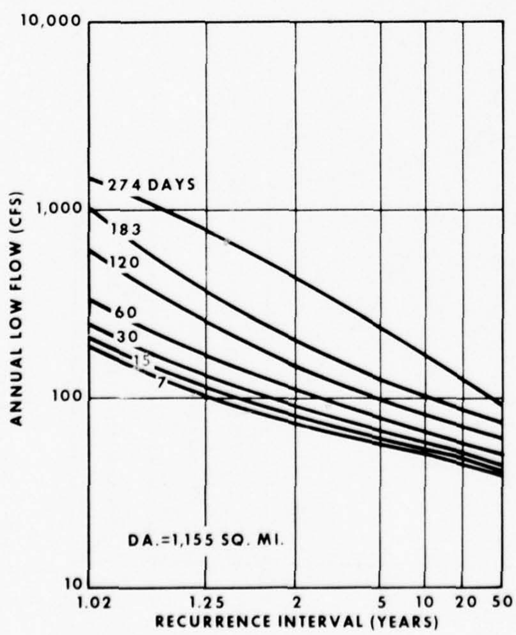
TYGART RIVER AT BELINGTON, W.VA.



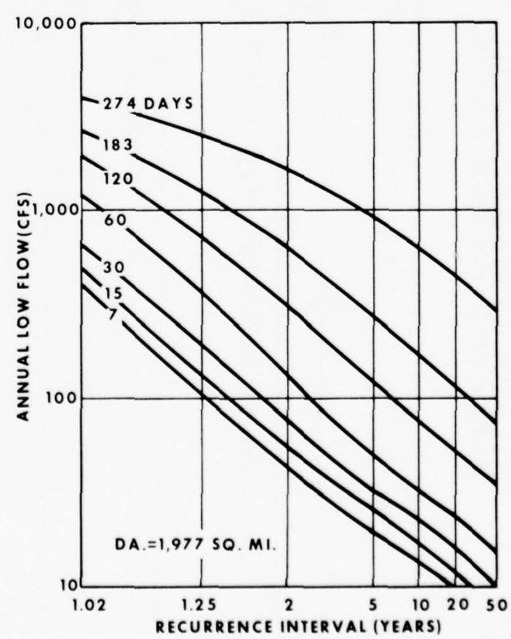
LICKING RIVER AT CATAWBA, KY.



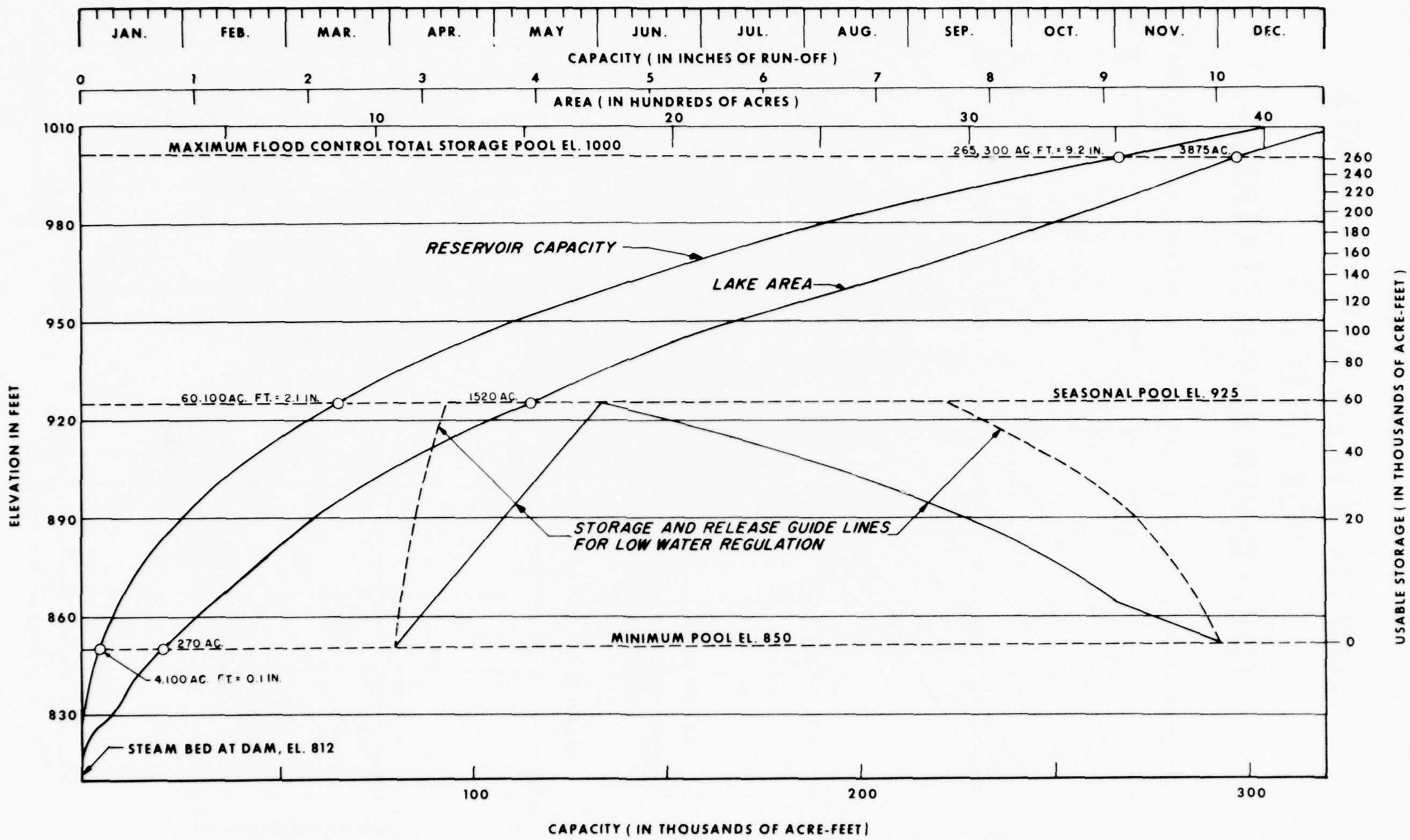
MIAMI RIVER AT TAYLORSVILLE, O.



CUMBERLAND RIVER AT CUMBERLAND FALLS, KY.

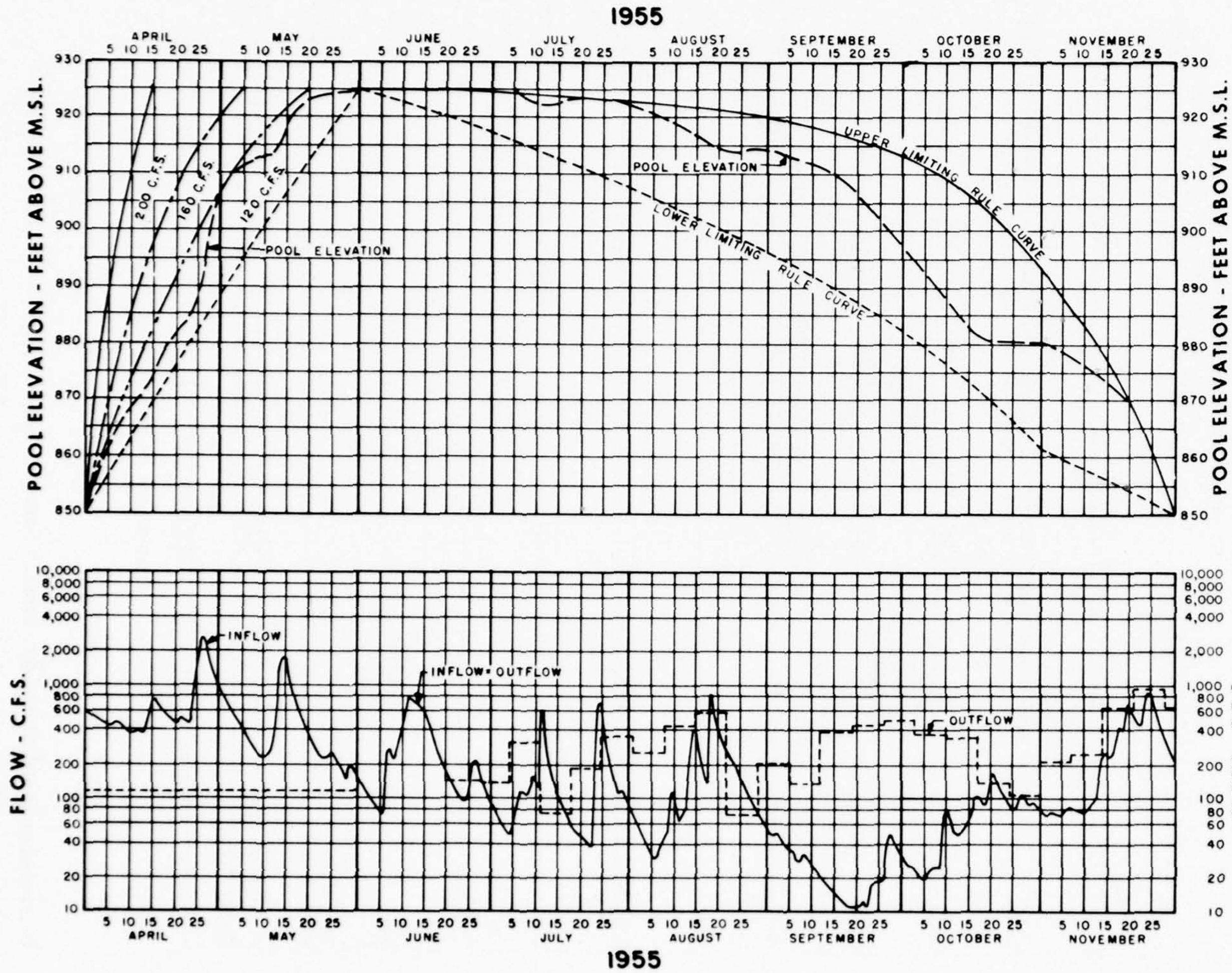


SUTTON RESERVOIR, ELK RIVER, KANAWHA RIVER BASIN



TYPICAL AREA CAPACITY RELATIONS
AND
LOW WATER REGULATION SCHEDULE

SUTTON RESERVOIR, ELK RIVER, KANAWHA RIVER BASIN



NOTES

(1) Minimum outflow of 75 C.F.S. maintained at all times.
(2) Outflow of 120 C.F.S. maintained during April and May in accordance with release indicated by *rule curves*.
(3) Releases for pollution abatement based on 0.286 of required flow augmentation and limited to a maximum flow augmentation of 400 C.F.S.
(4) When inflow was greater than scheduled outflow, pool was lowered in accordance with upper limiting rule curve.

TYPICAL
LOW-FLOW REGULATION
APRIL-NOVEMBER 1955

MANSFIELD RESERVOIR - RACCOON CREEK - WABASH RIVER BASIN

TYPICAL AREA CAPACITY RELATIONS AND POOL REGULATION SCHEDULE

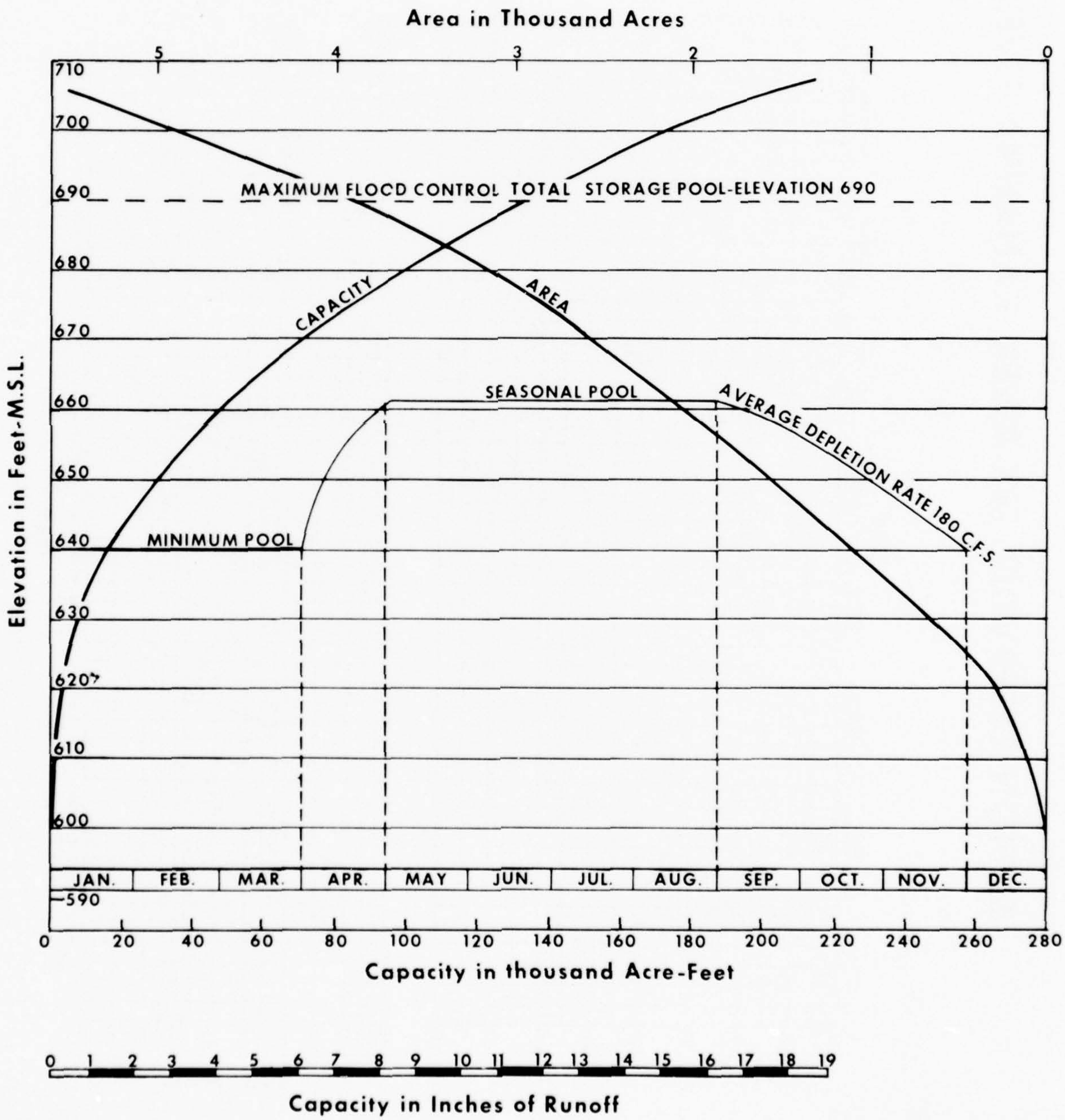
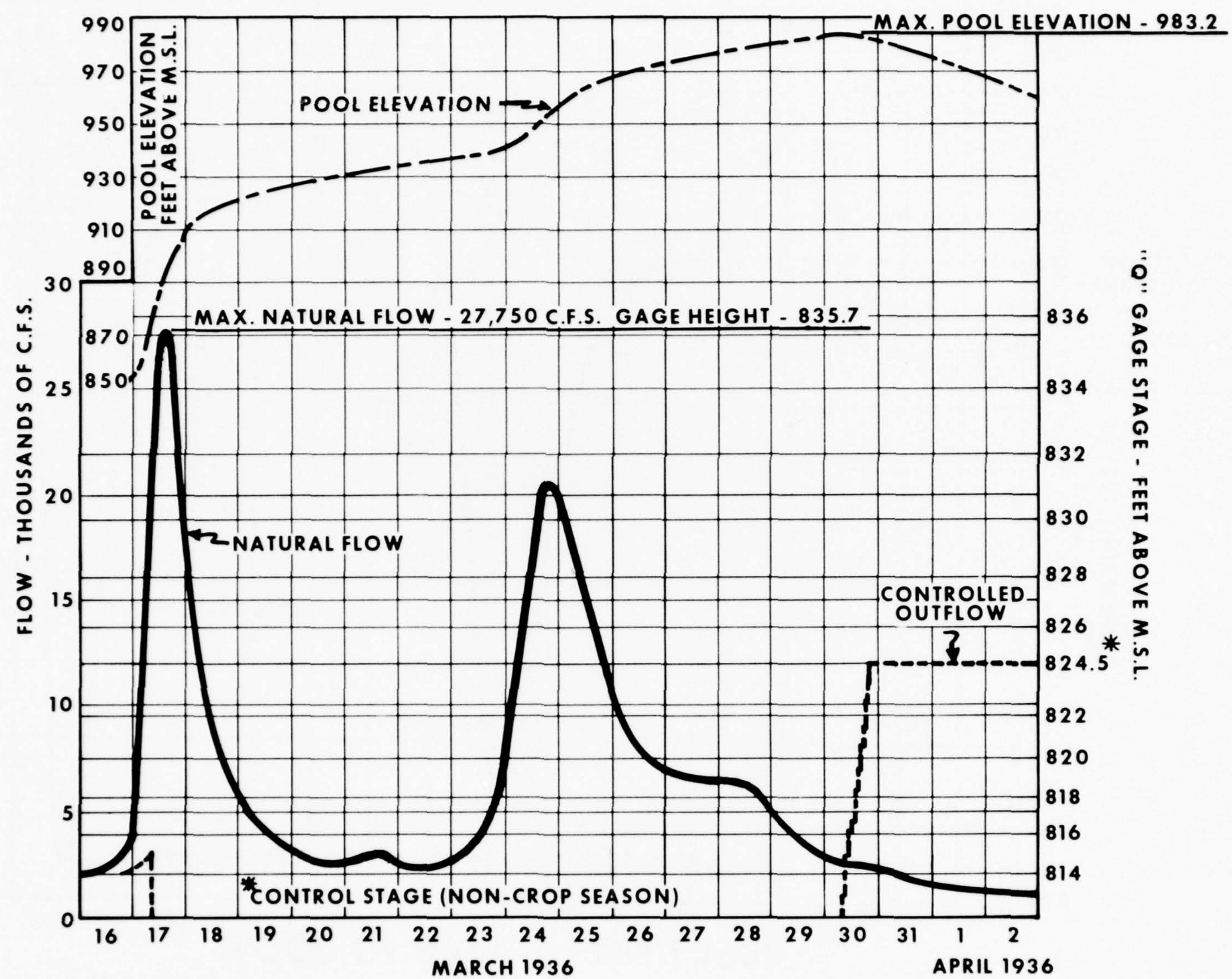
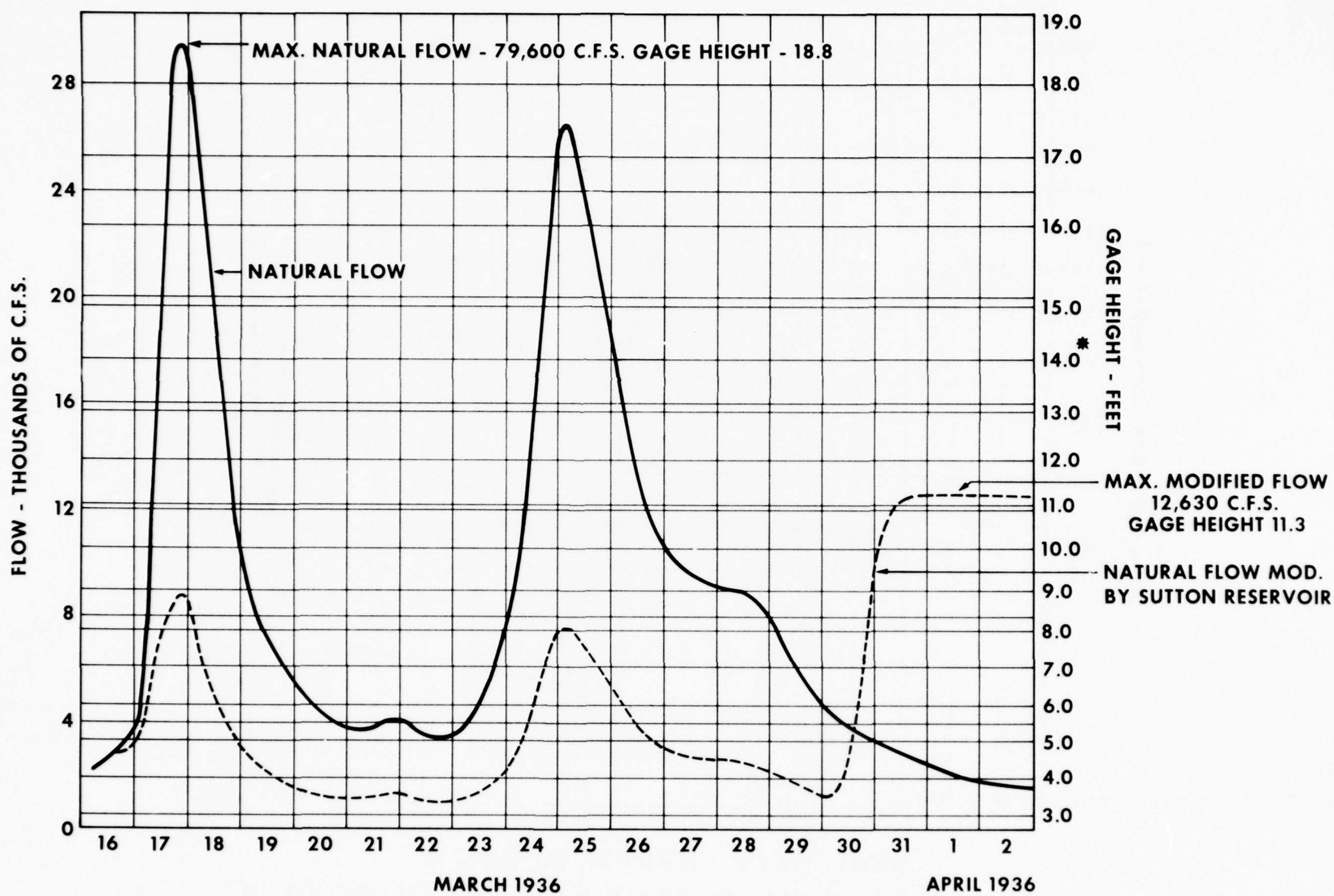


PLATE 24

HYDROGRAPH FOR ELK RIVER, W. VA. AT SUTTON DAM
FLOOD OF MARCH - APRIL, 1936



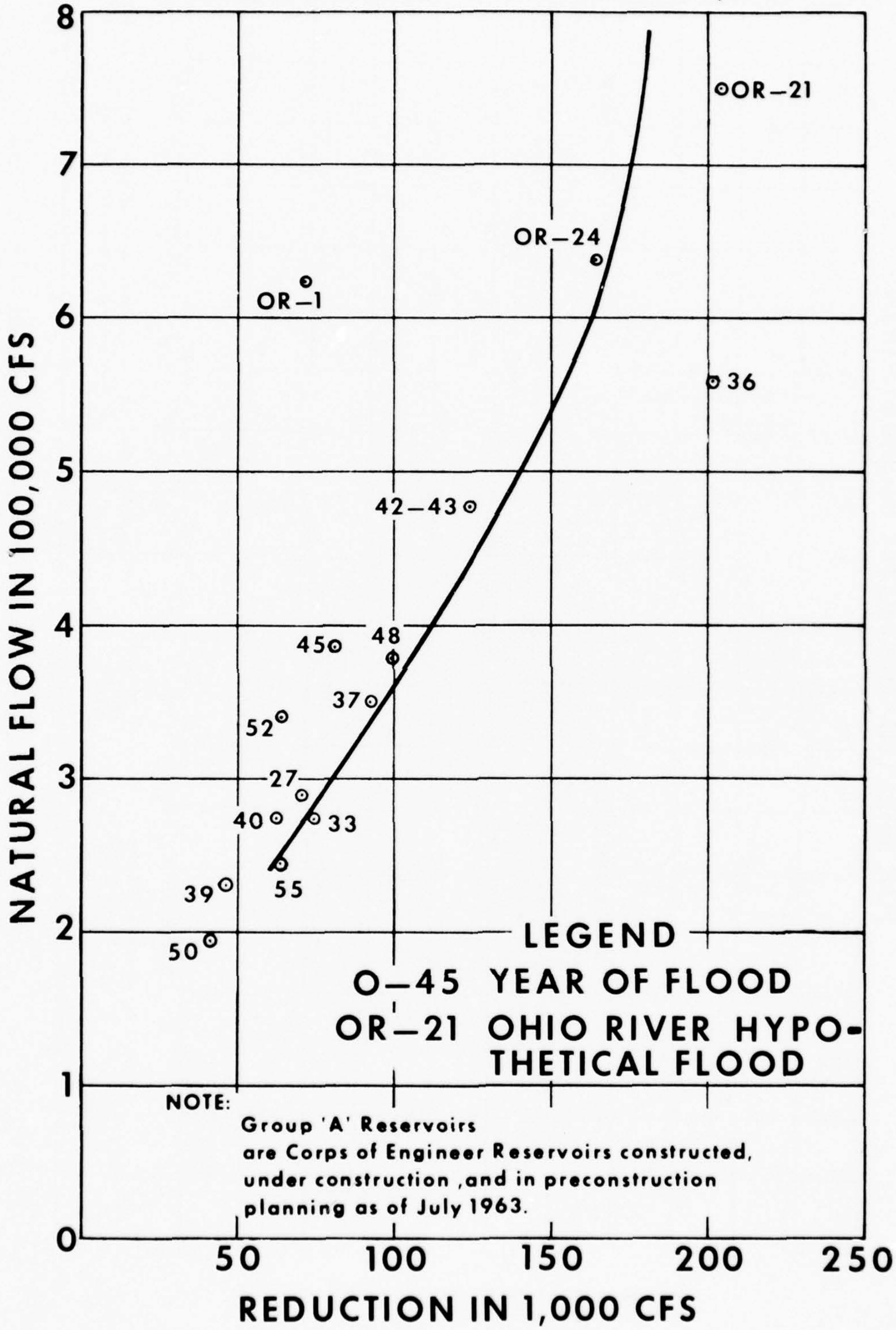
HYDROGRAPH FOR ELK RIVER, AT FRAMETOWN, W. VA.
FLOOD OF MARCH - APRIL 1936



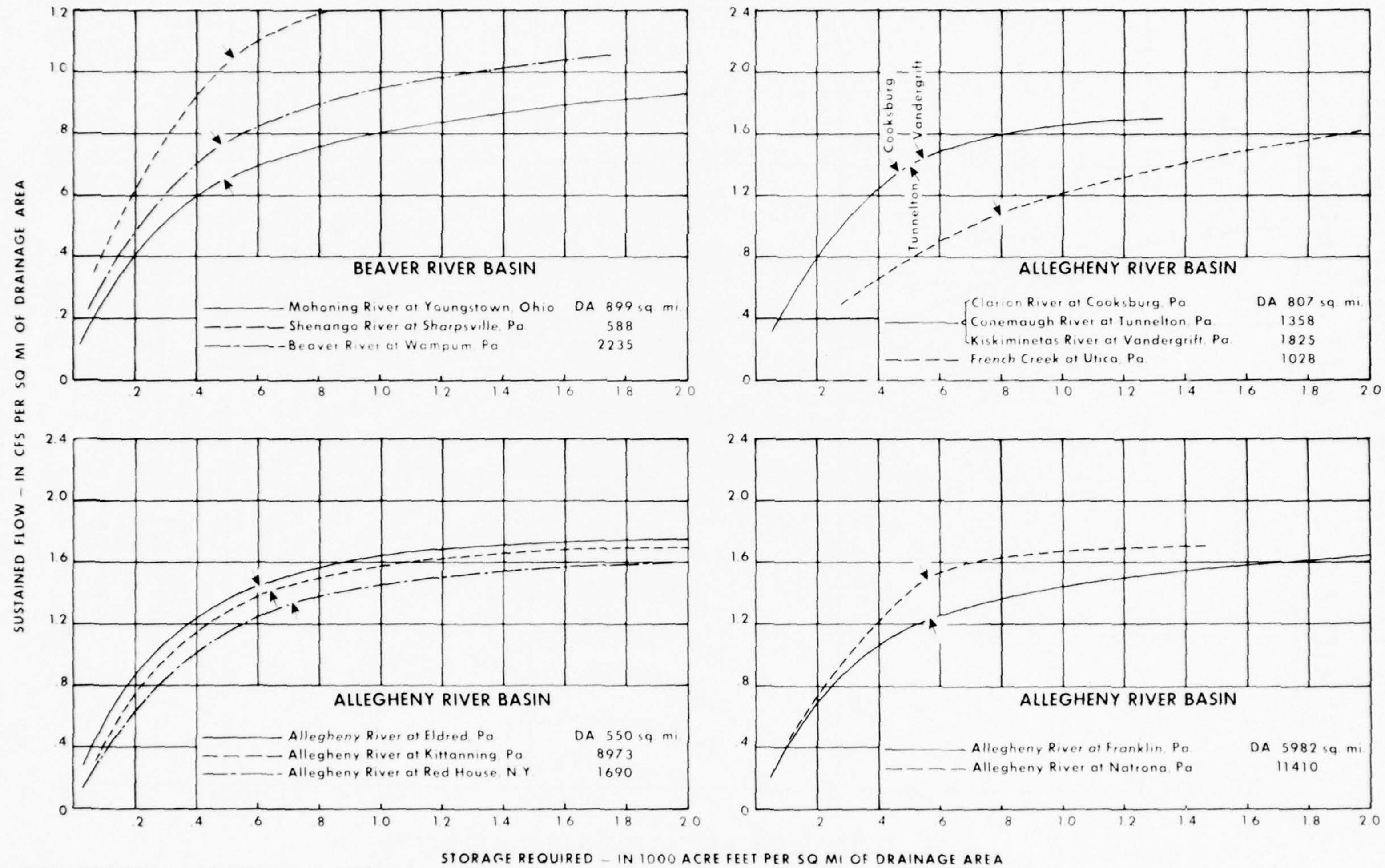
*CONTROL STAGE (NON - CROP SEASON)

GROUP "A" RESERVOIR AVERAGE REDUCTIONS IN FLOOD PEAK DISCHARGE

OHIO RIVER AT PITTSBURGH, PA.

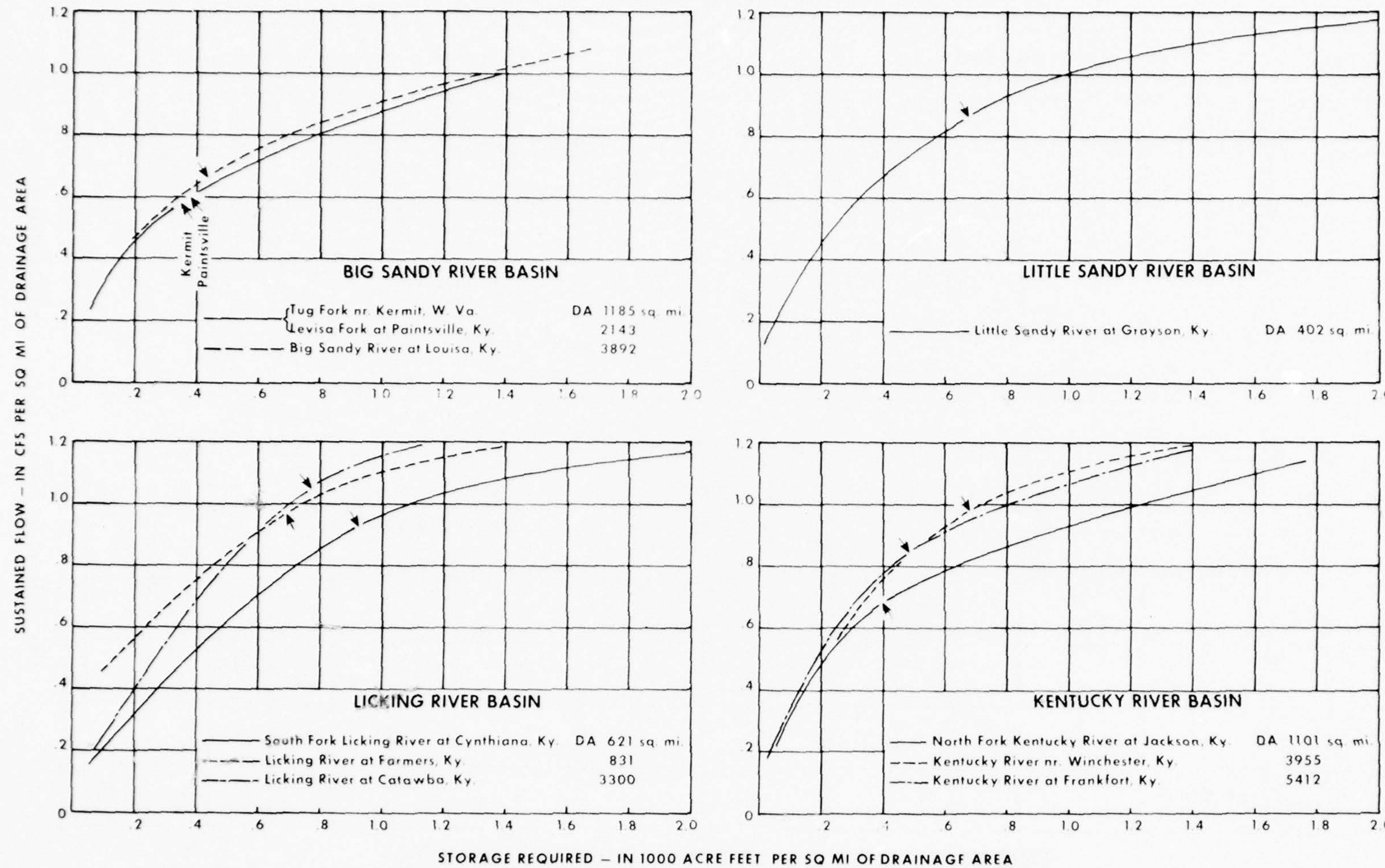


FLOW STORAGE CURVES
FOR SELECTED OHIO RIVER BASIN STATIONS



▲ INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

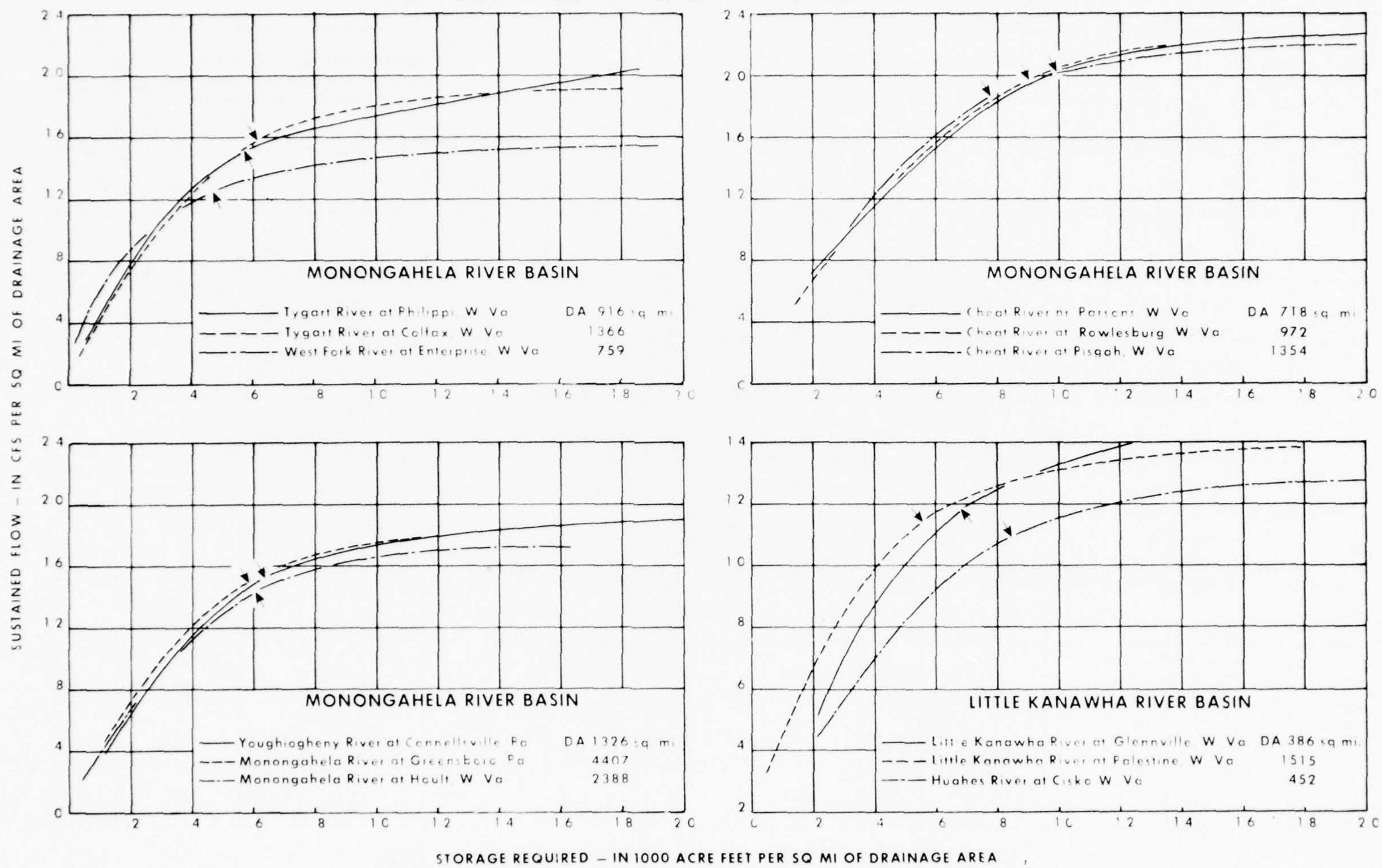
FLOW STORAGE CURVES
FOR SELECTED OHIO RIVER BASIN STATIONS



↑INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

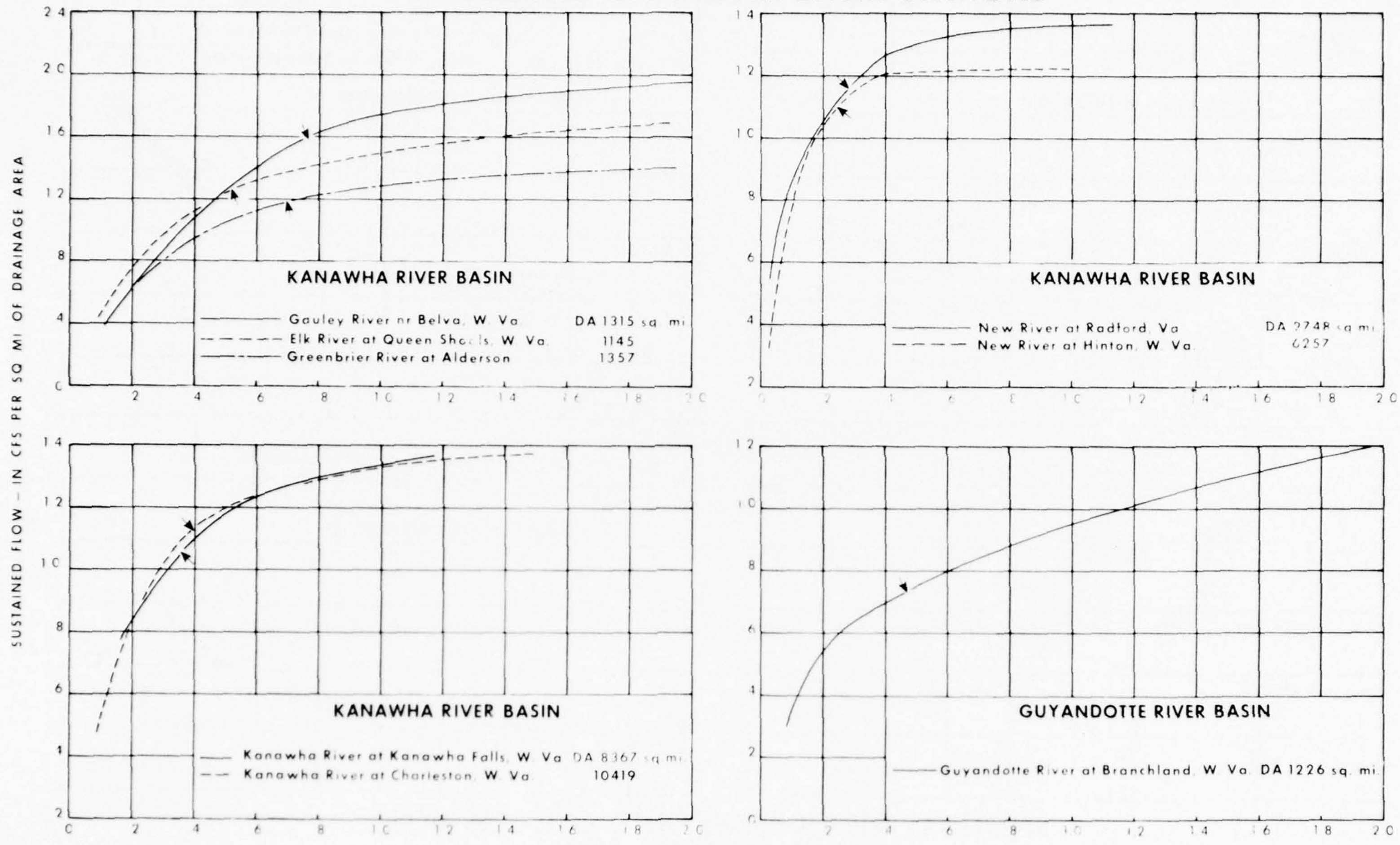
PLATE 28b

FLOW STORAGE CURVES
FOR SELECTED OHIO RIVER BASIN STATIONS



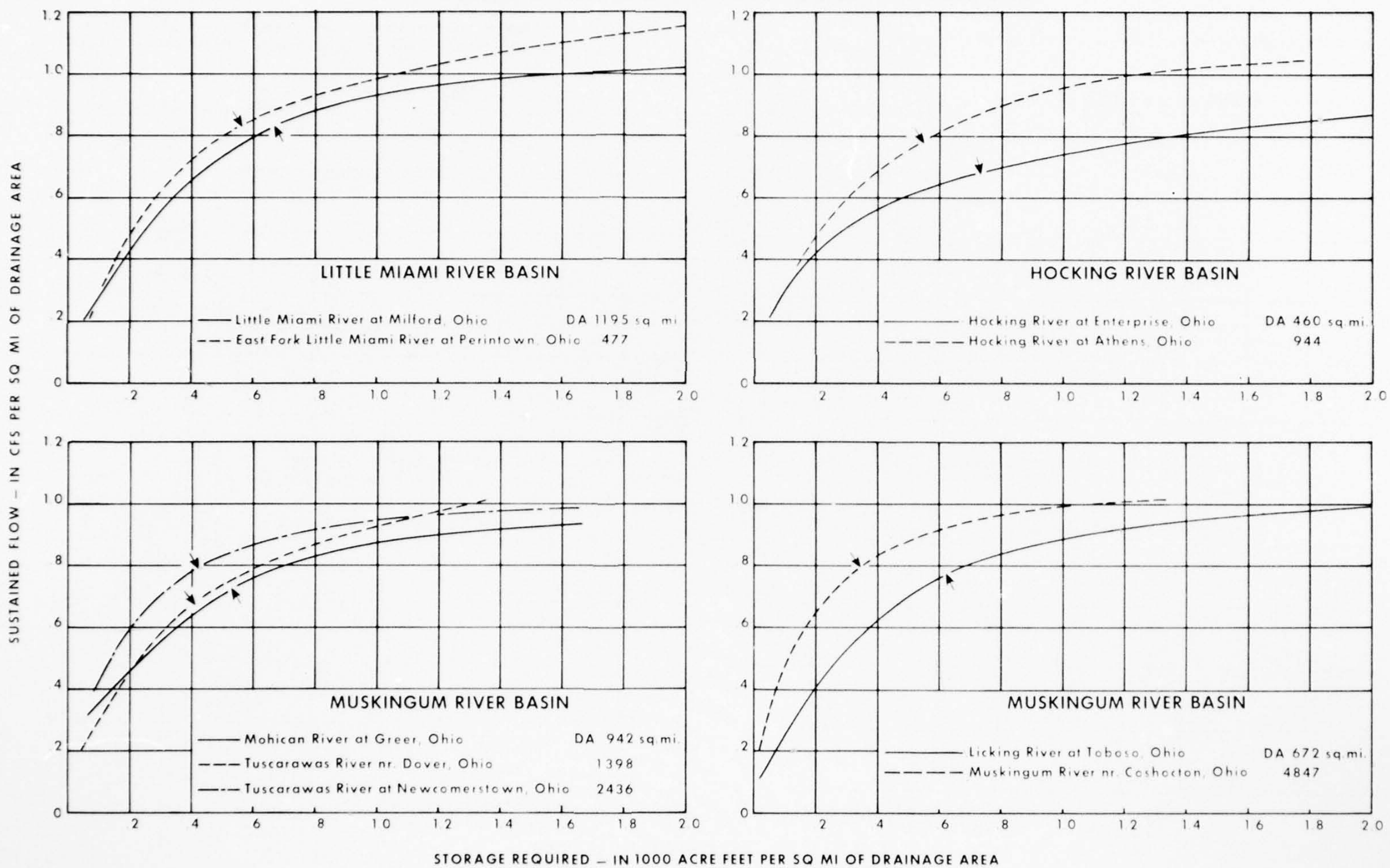
▲ INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

FLOW STORAGE CURVES FOR SELECTED OHIO RIVER BASIN STATIONS



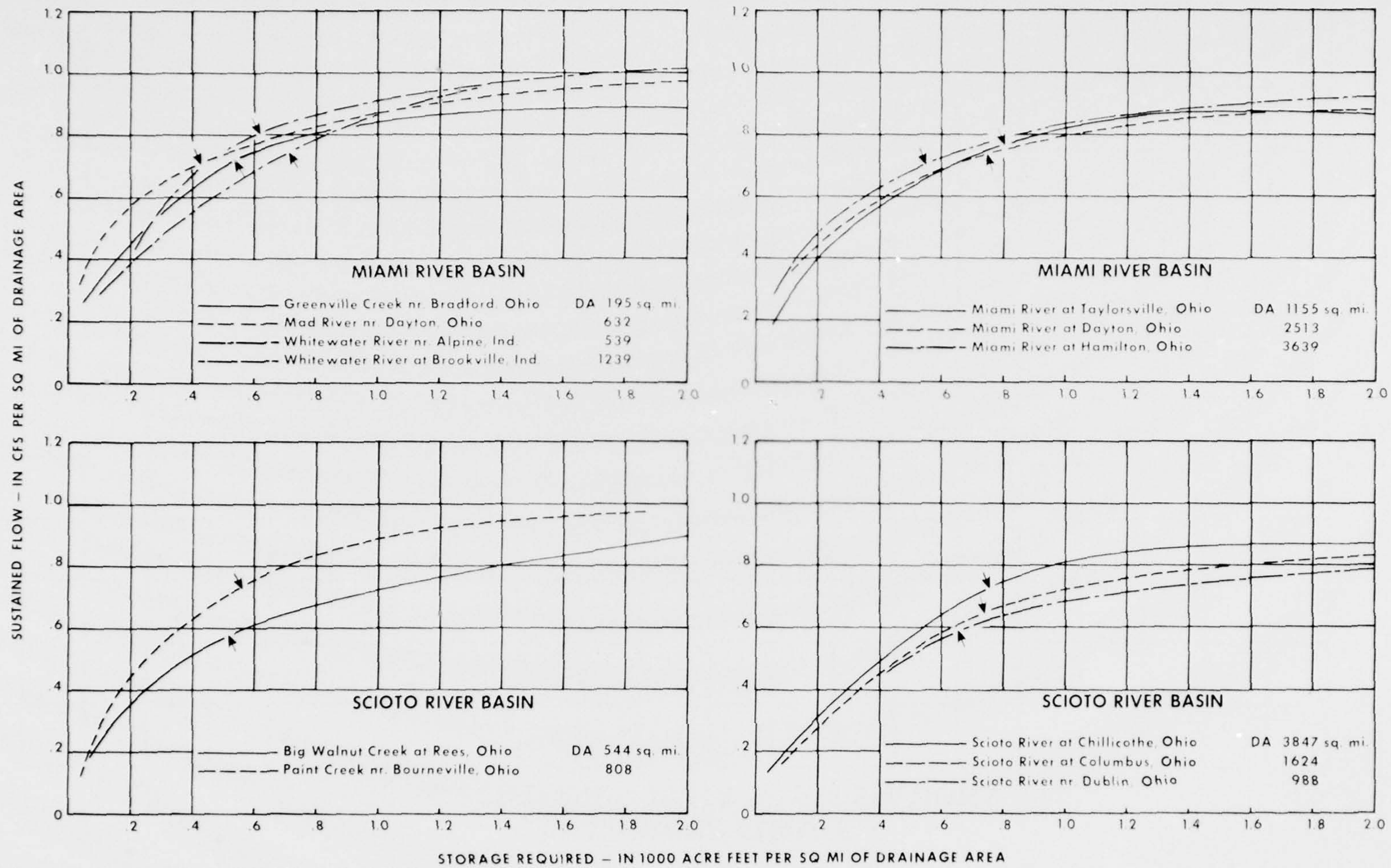
↑ INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

FLOW STORAGE CURVES
FOR SELECTED OHIO RIVER BASIN STATIONS



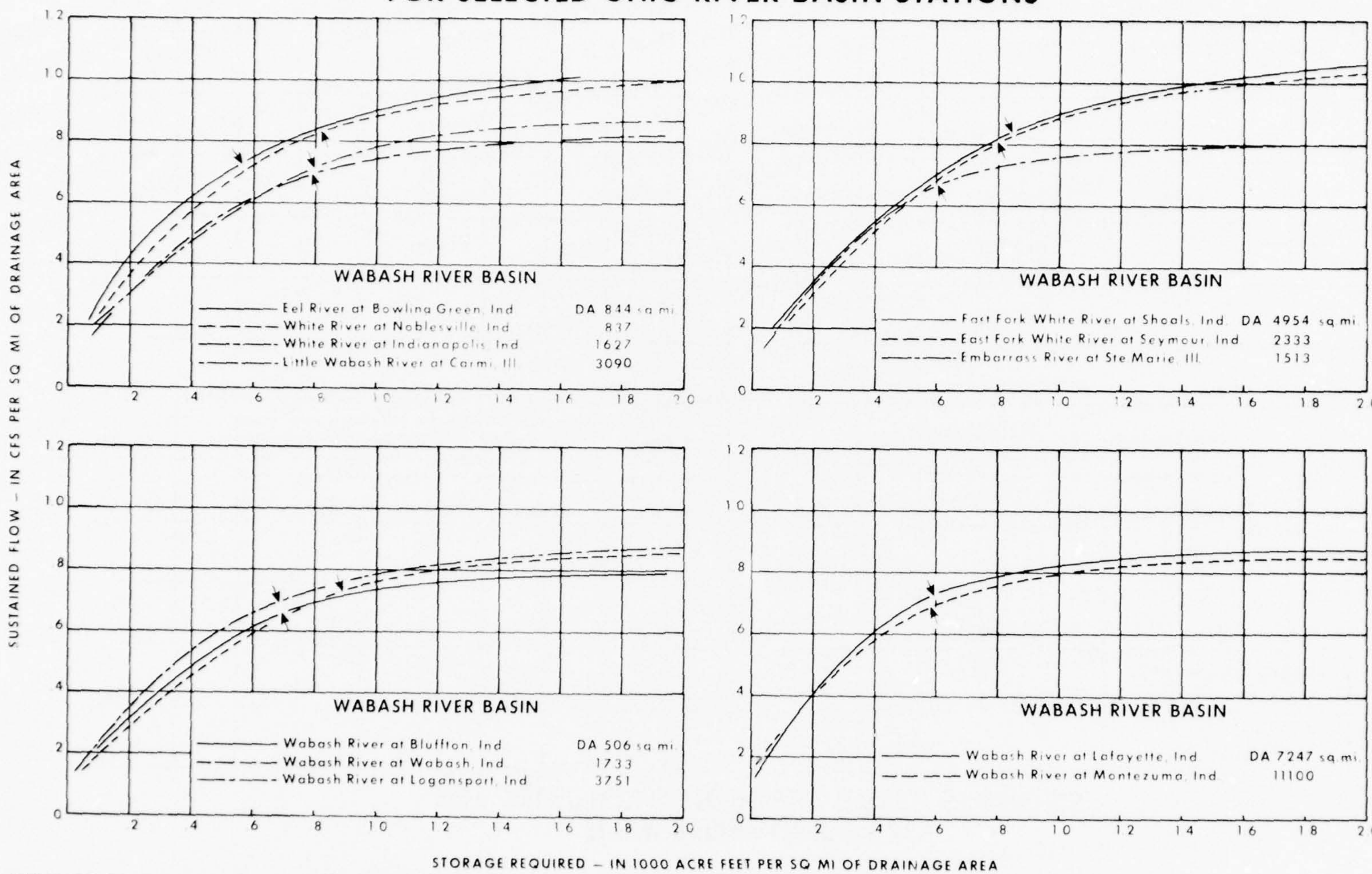
↓ INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

FLOW STORAGE CURVES
FOR SELECTED OHIO RIVER BASIN STATIONS



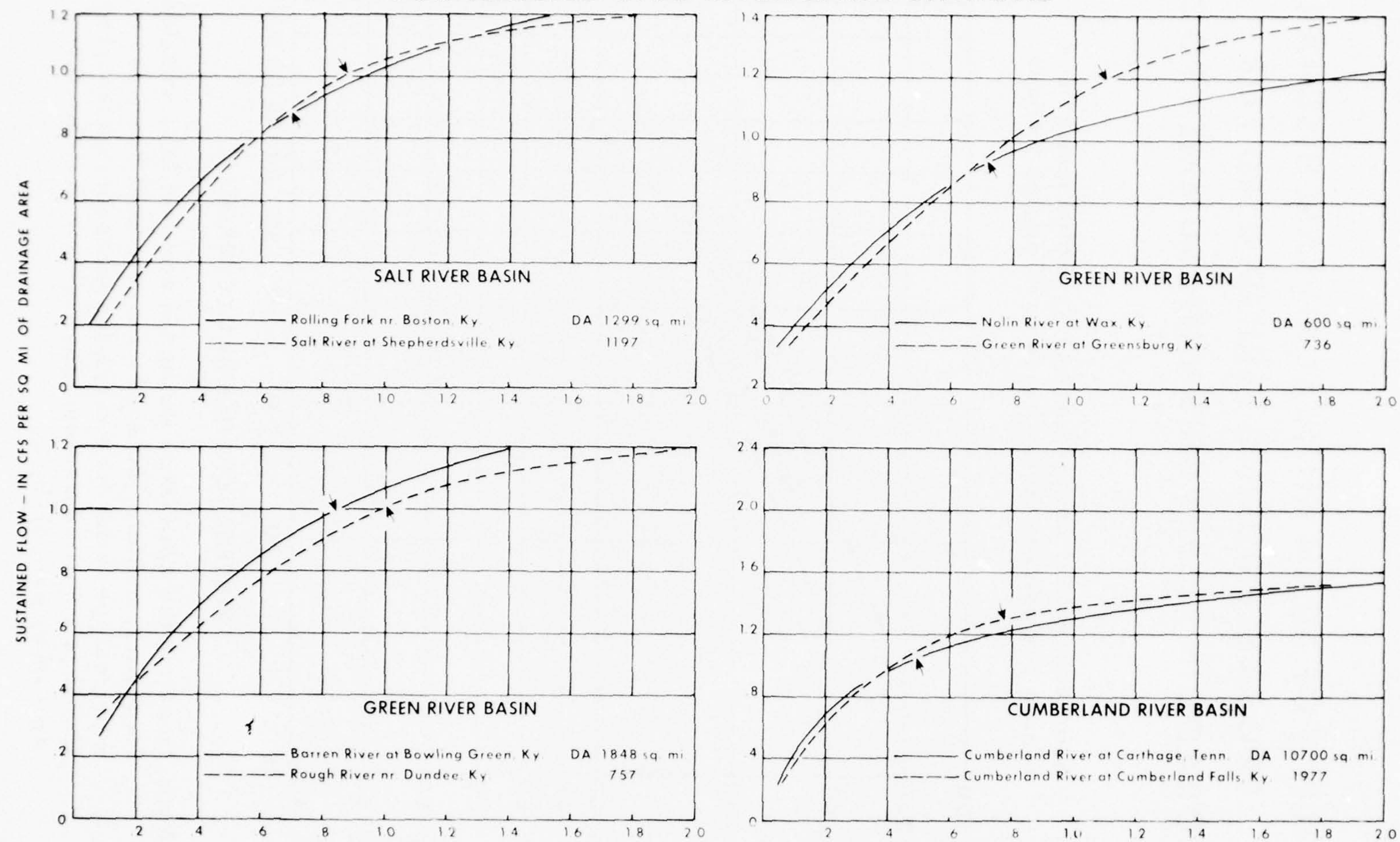
↑ INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

FLOW STORAGE CURVES
FOR SELECTED OHIO RIVER BASIN STATIONS



↑ INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

FLOW STORAGE CURVES
FOR SELECTED OHIO RIVER BASIN STATIONS

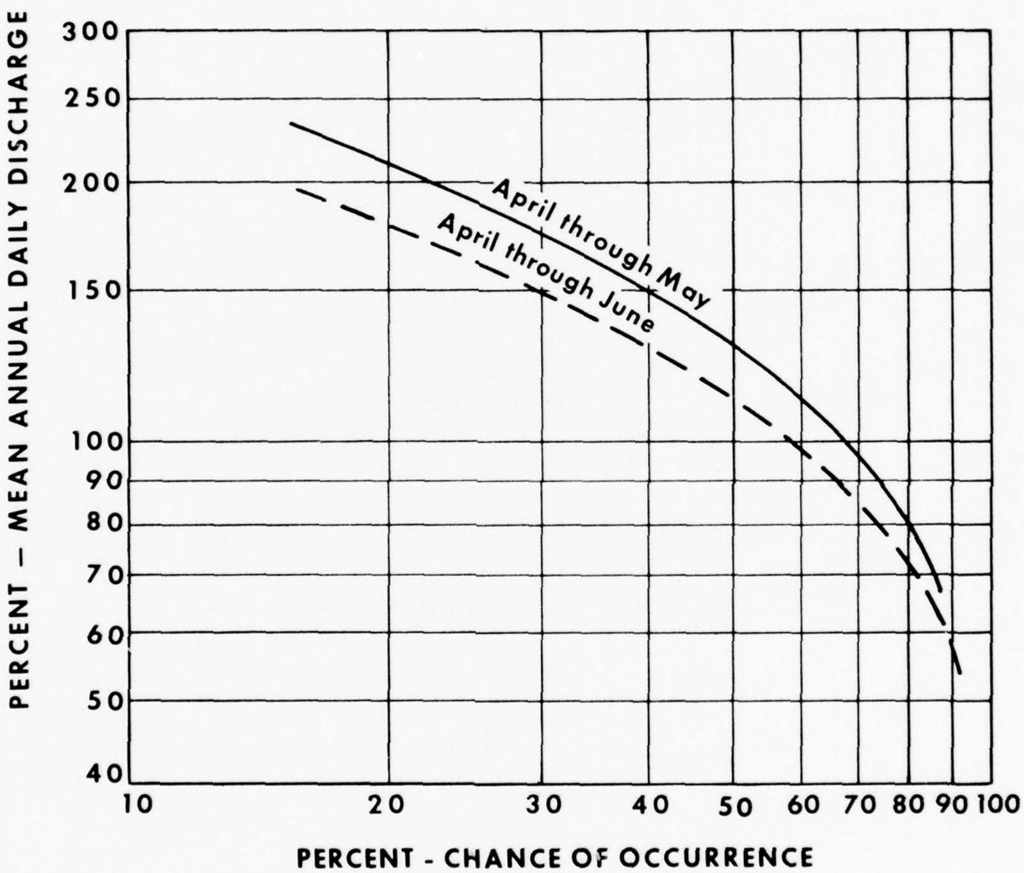


↑ INDICATES OPTIMUM FLOW STORAGE DEVELOPMENT

PLATE 28h

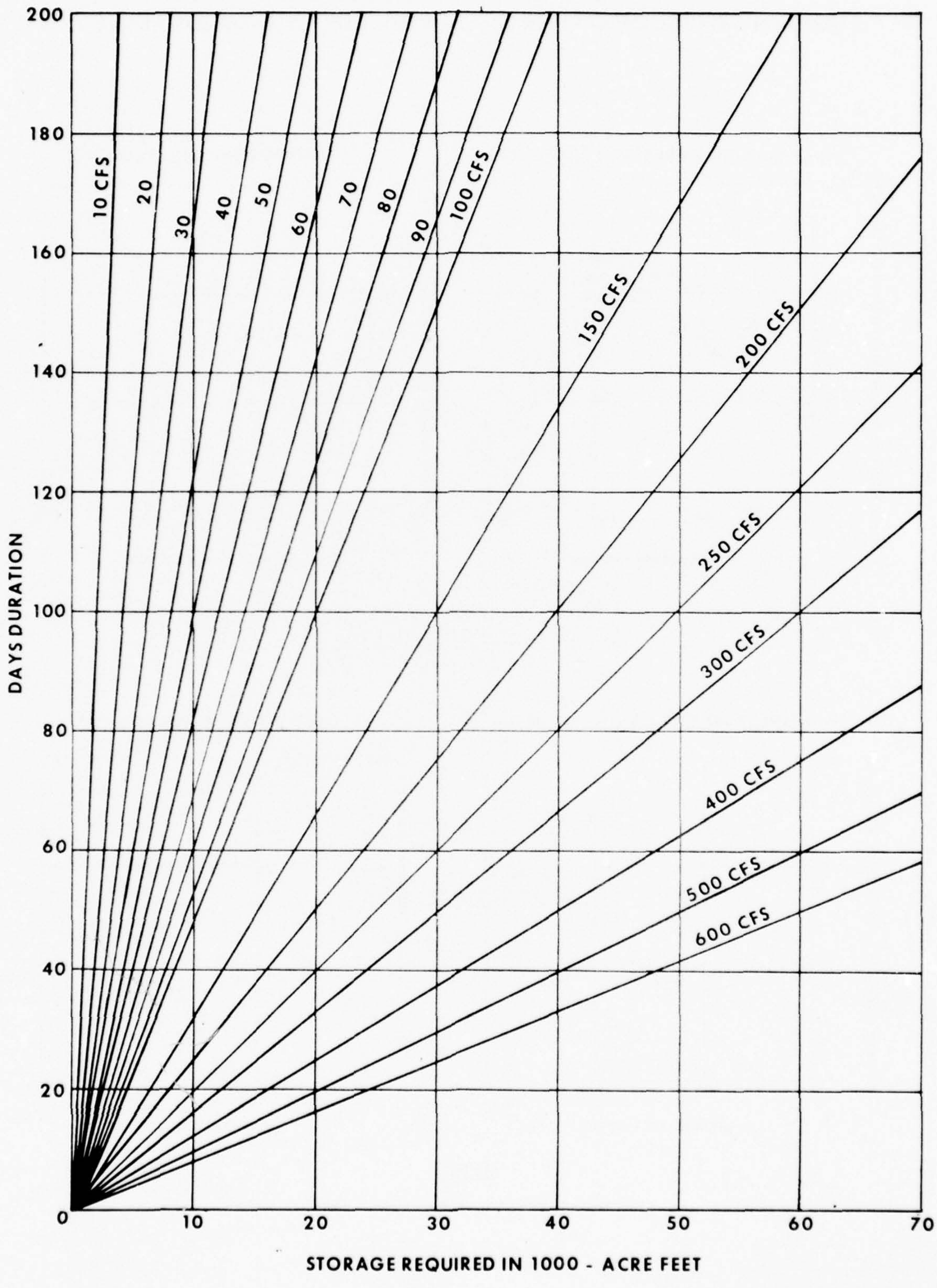
PERCENT OF MEAN ANNUAL STREAM DISCHARGE PROBABLE DURING PERIOD USED FOR STORAGE IN RESERVOIRS WITH SUMMER POOLS

Assumes seasonal storage begins 1 April after major flood season has passed. Curves based on 10 gaging stations.



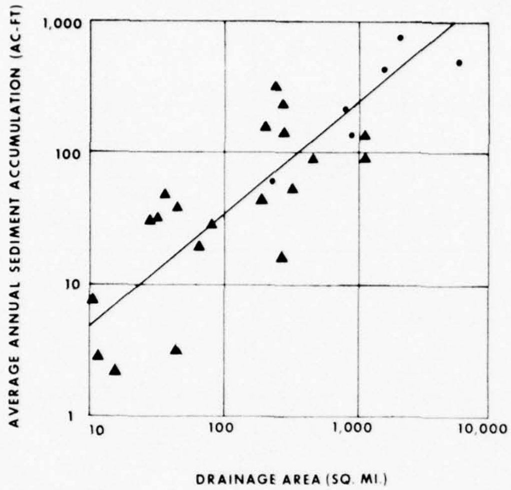
Note : To obtain the April-May storage in acre feet for a selected frequency, multiply [(60 days x mean annual discharge in cfs x percentage factor from curve for pertinent frequency) minus (60 days x desired average daily release in cfs for the April-May period)] by 2.

RESERVOIR STORAGE REQUIRED TO MAINTAIN A SPECIFIC FLOW FOR AN INDICATED NUMBER OF DAYS

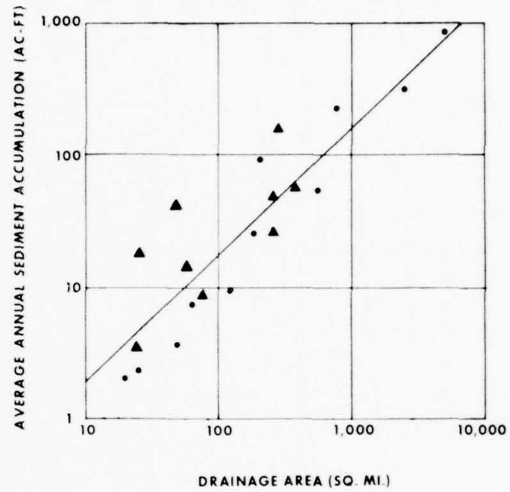


(1) GENERALIZED RESERVOIR SEDIMENTATION CURVES FOR OHIO RIVER BASIN PHYSIOGRAPHIC PROVINCES AND (2) TYPICAL OHIO RIVER DISCHARGE-SUSPENDED SOLIDS CURVE

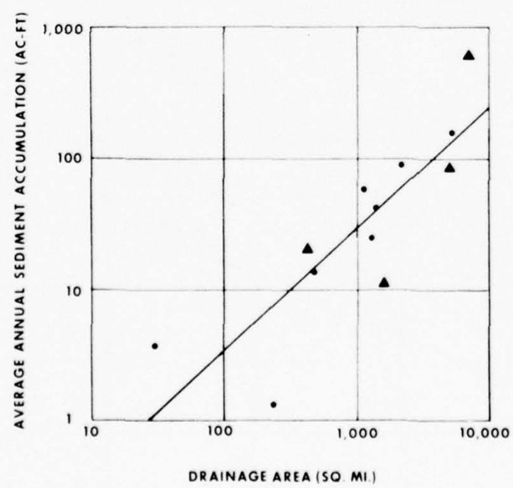
(1) APPALACHIAN PLATEAU PROVINCE



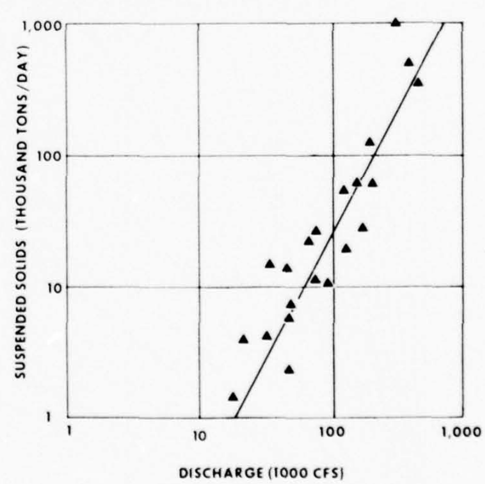
(1) CENTRAL LOWLAND PROVINCE



(1) INTERIOR LOW PLATEAUS PROVINCE



(2) OHIO RIVER AT AURORA, IND.

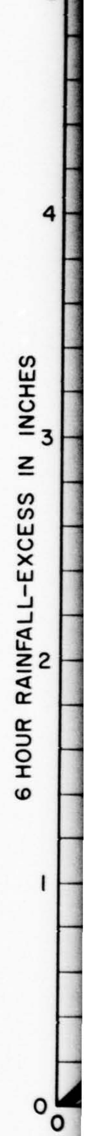


LEGEND

• Reservoir Sediment ▲ Suspended Sediment (Line is Computed)

OHIO RIVER PROJECT FLOO

INFILTRATION INDICES AN



INFILTRATION INDICES

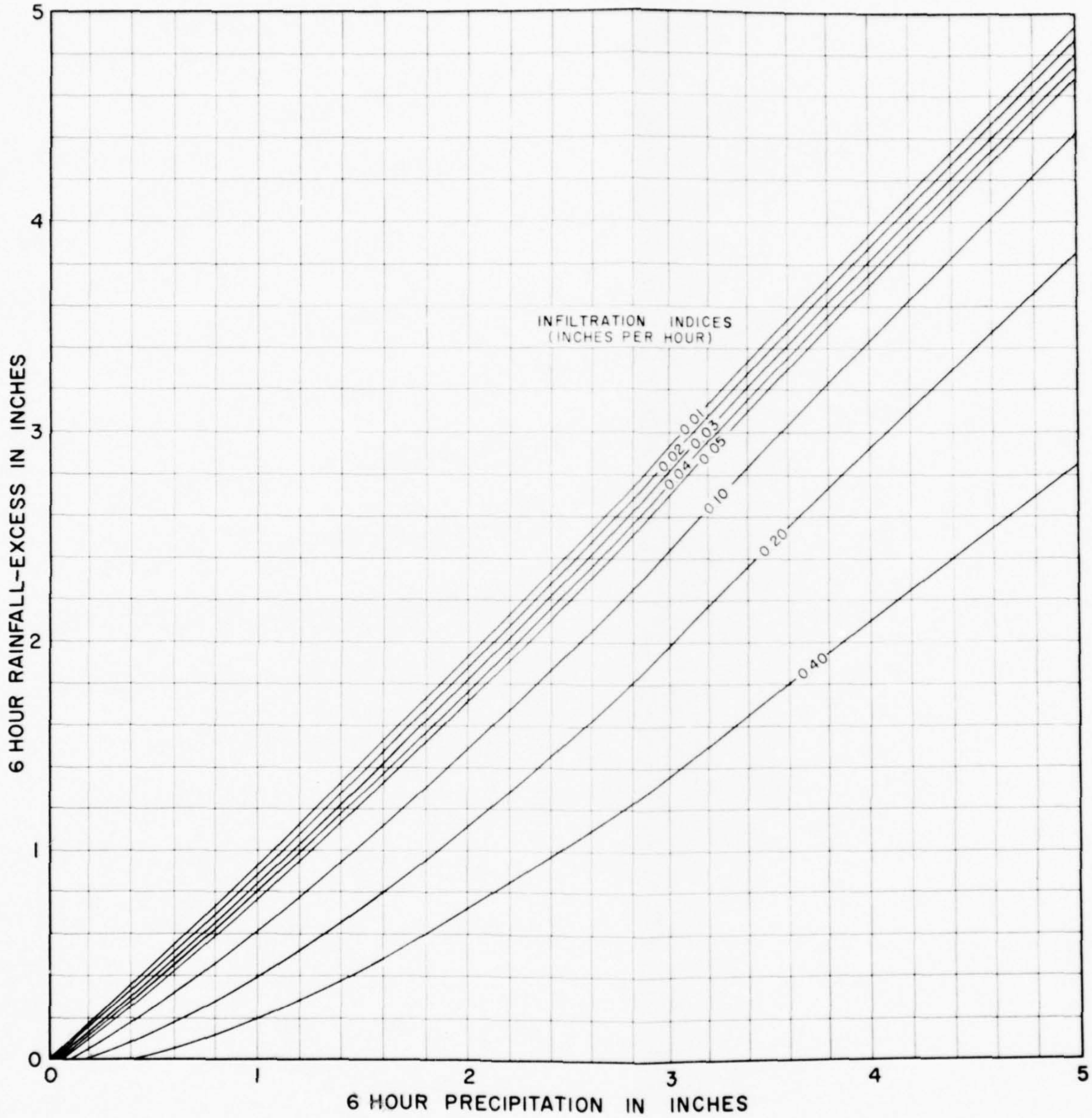
		BASE FLOWS IN C.F.S.						
STATION	DRAINAGE AREA SQ. MI.	JAN. JULY	FEB. MAR. JUNE	APR. MAY	SEPT. OCT. NOV.	AUG. DEC.	STATION	DRAINAGE AREA SQ. MI.
PITTSBURGH, PA.	19,100	7,800	8,900	10,000	5,600	6,700	MAYSVILLE, KY.	70,130
WELLSVILLE, O.	23,500	9,300	10,700	12,000	6,700	8,000	CINCINNATI, O.	76,580
WHEELING, W.VA.	24,660	10,000	11,500	13,000	7,400	8,700	LOUISVILLE, KY.	91,170
ST. MARYS, W.VA.	26,850	11,000	12,400	14,000	8,000	9,400	EVANSVILLE, IND.	107,050
POMEROY, O.	40,500	15,400	18,700	21,000	11,700	14,000	GOLCONDA, ILL.	143,660
HUNTINGTON, W.VA.	55,600	22,000	25,000	28,000	15,600	18,700	METROPOLIS, ILL.	202,760

R PROJECT FLOOD STUDY

NDICES AND BASE FLOWS

ORK

IA



RAINFALL EXCESS CURVES

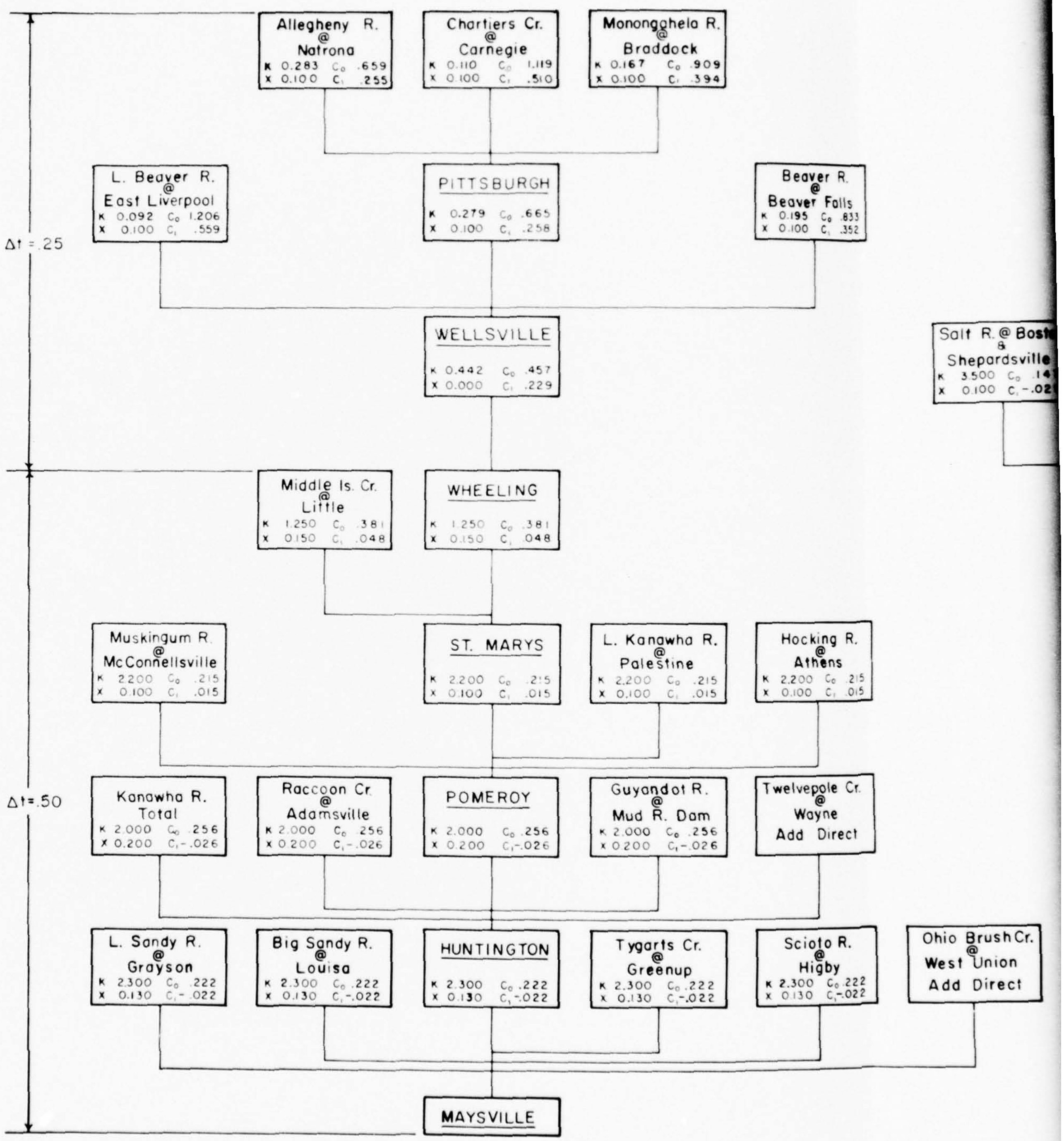
ON	DRAINAGE AREA SQ. MI.	JAN. JULY	FEB. MAR. JUNE	APR. MAY	SEPT. OCT. NOV.	AUG. DEC.
KY.	70,130	26,600	30,000	34,000	19,000	22,600
O.	76,580	29,000	33,000	37,000	20,600	24,600
KY.	91,170	32,700	38,000	43,000	24,000	28,600
, IND.	107,050	38,000	43,500	49,000	27,000	32,600
ILL.	143,660	51,000	59,000	65,000	36,000	43,300
ILL.	202,760	70,000	80,000	90,000	50,000	60,000

PLATE 32

2

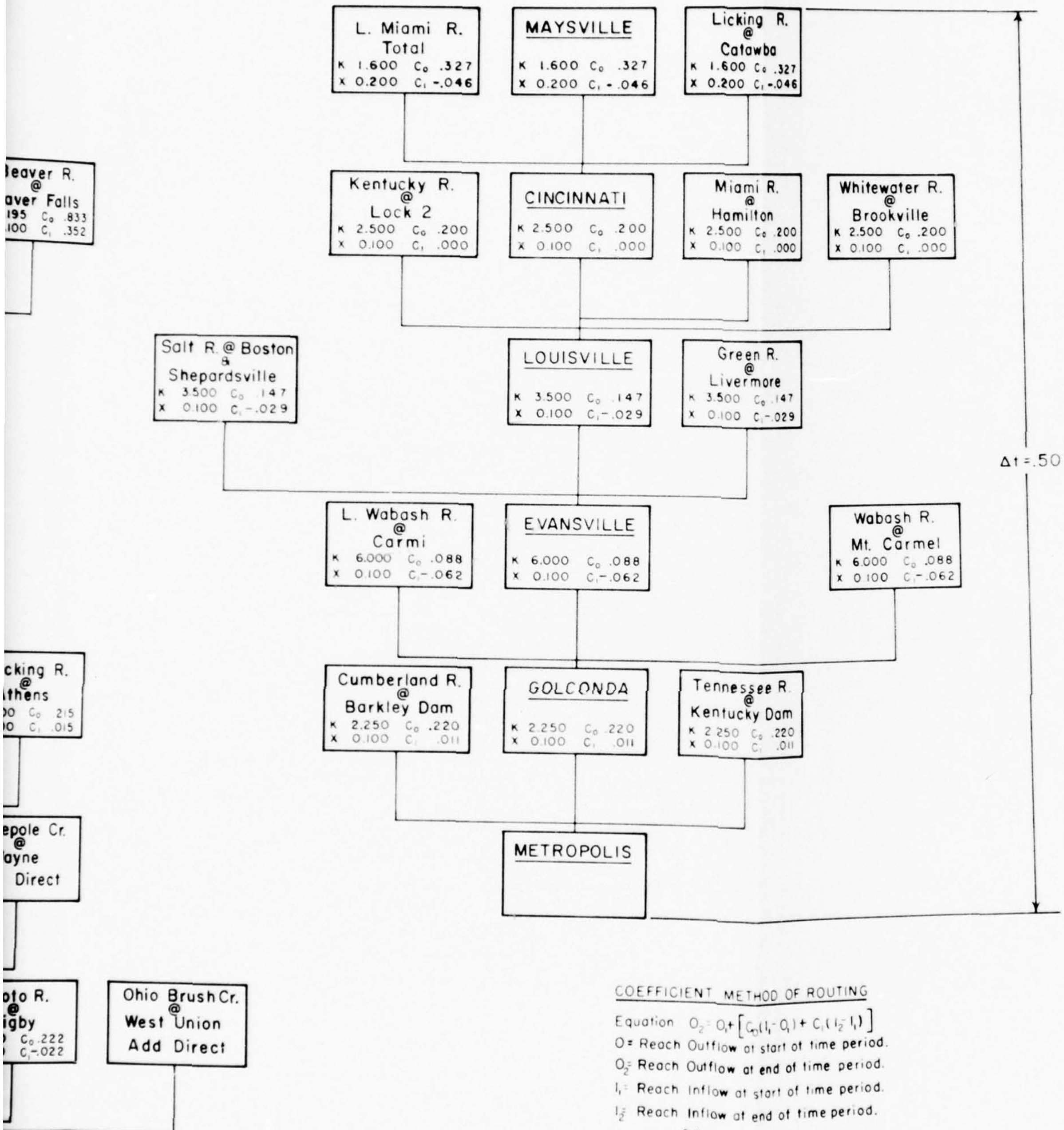
OHIO RIVER PROJECT FLOOD S

OHIO RIVER ROUTING R



ɪIVER PROJECT FLOOD STUDY

ʏER ROUTING REACHES



COEFFICIENT METHOD OF ROUTING

Equation $O_2 = O_1 + \left[C_0 (I_1 - O_1) + C_1 (I_2 - I_1) \right]$

O_1 = Reach Outflow at start of time period.

O_2 = Reach Outflow at end of time period.

I_1 = Reach Inflow at start of time period.

I_2 = Reach Inflow at end of time period.

$$C_0 = \frac{2\Delta t}{2K(1-X)+\Delta t}$$

$$C_1 = \frac{\Delta t - 2KX}{2K(1-X)+\Delta t}$$

Δt = Time period in days.

K & X = Constants.

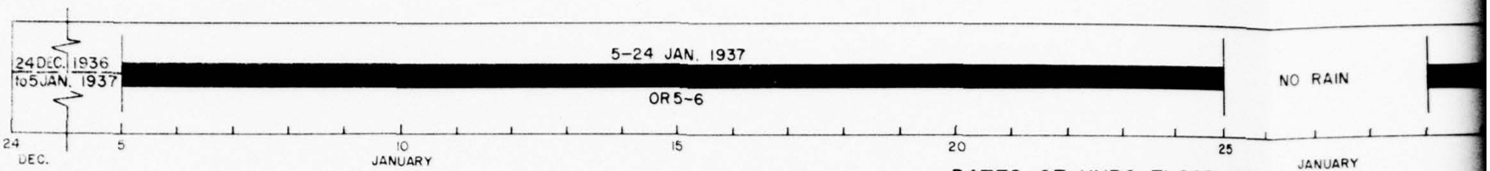
PLATE 33

2

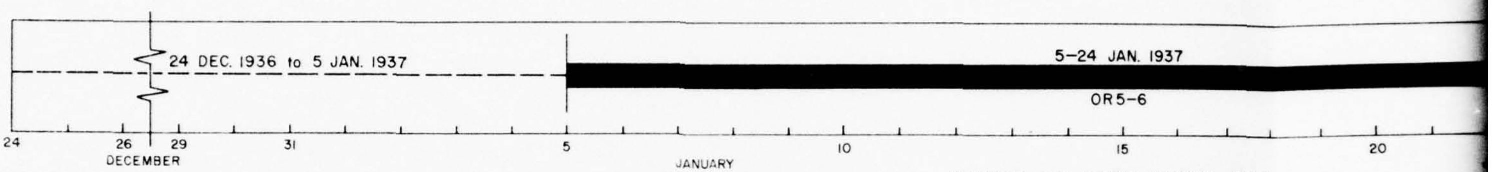
OHIO RIVER PROJECT FLOOD ST

RAINFALL PERIODS - HYPOTHE

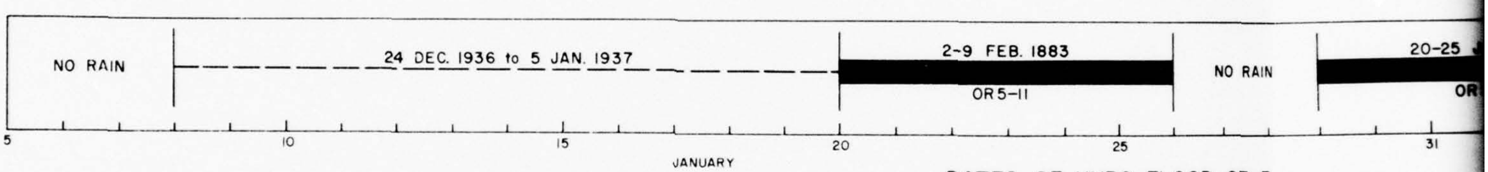
DATES OF RAINFALL PERIOD FOR STORM COMBINATION



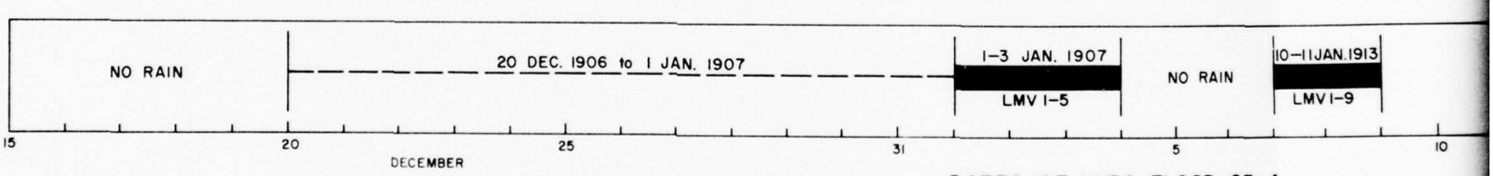
DATES OF HYPO-FLOOD OR-1



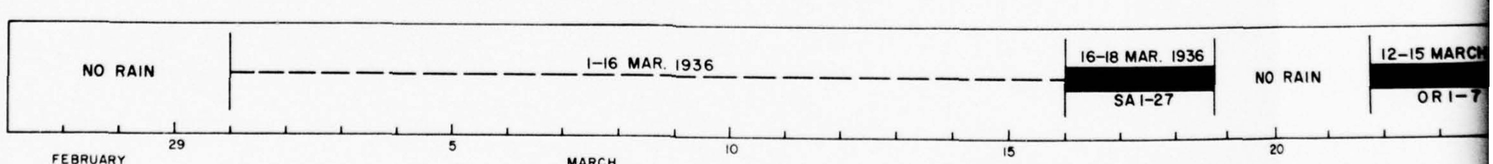
DATES OF HYPO-FLOOD OR-2



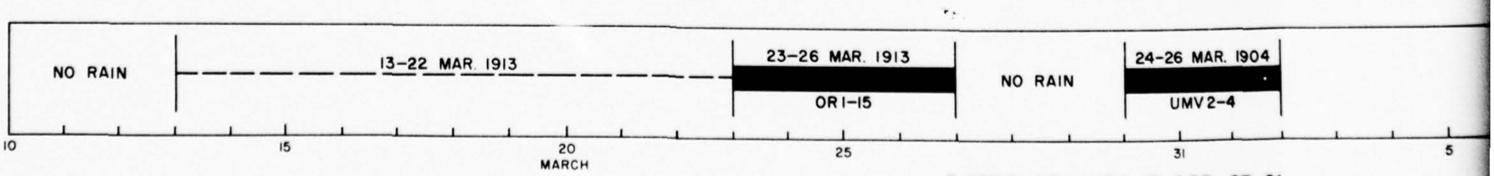
DATES OF HYPO-FLOOD OR-3



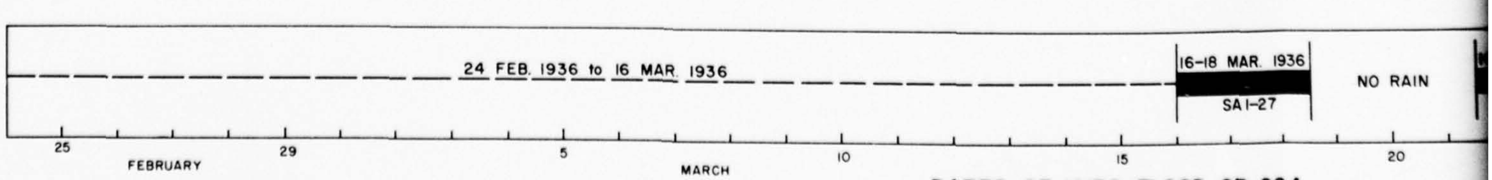
DATES OF HYPO-FLOOD OR-4



DATES OF HYPO-FLOOD OR-20



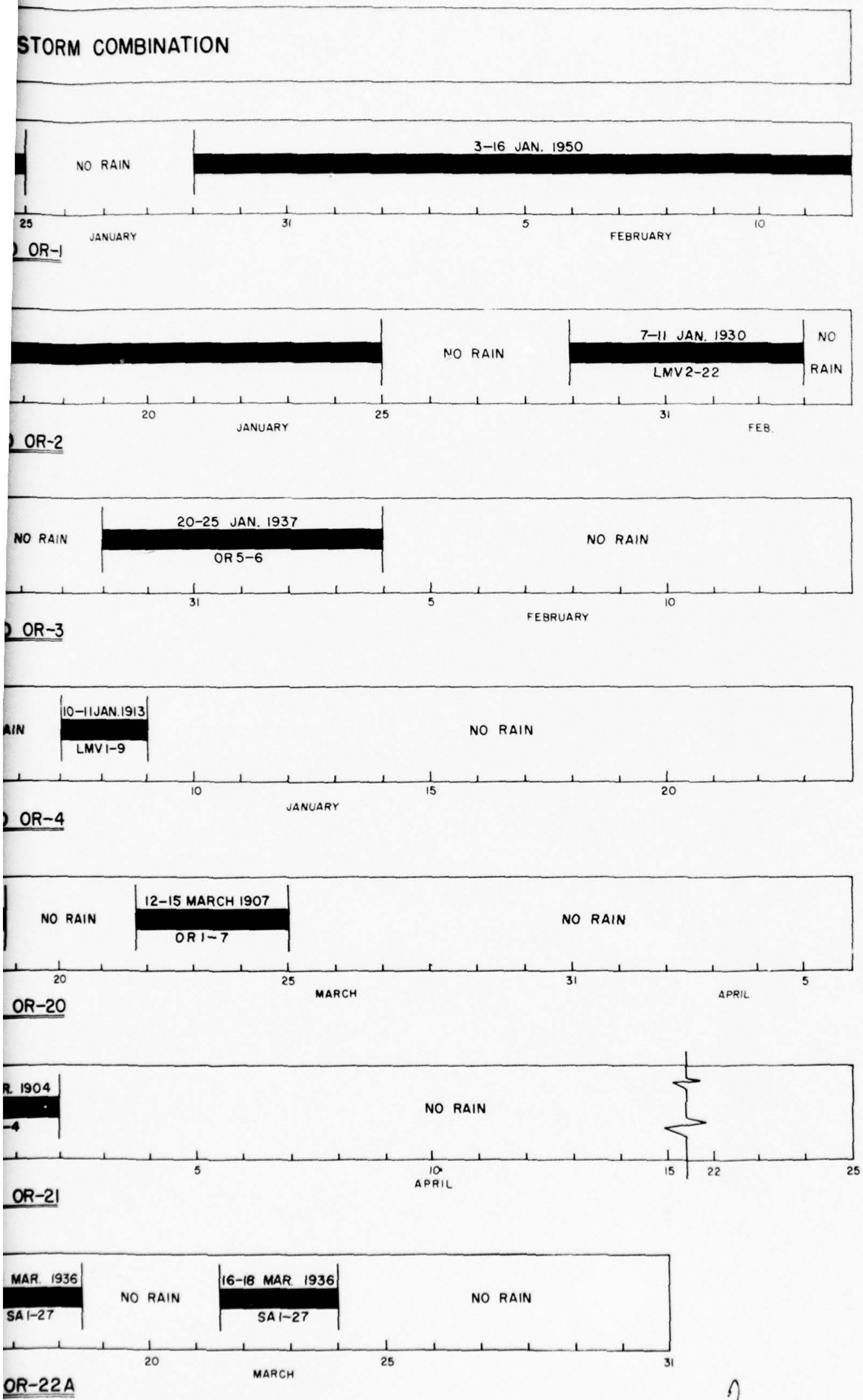
DATES OF HYPO-FLOOD OR-21



DATES OF HYPO-FLOOD OR-22A

ROJECT FLOOD STUDY

- HYPOTHETICAL FLOODS



NOTES:

(1) HYPO-FLOOD OR-1: STORM OR 5-6, CENTER TRANSPOSED FROM McKENZIE, TENN. 240 MI. E-NE. TO LITTLE HICKMAN, KY. NO ROTATION OR RAINFALL ADJUSTMENT.

(2) HYPO-FLOOD OR-2: STORM LMV 2-22, CENTER TRANSPOSED FROM BROWNSVILLE, TENN., 175 MI. NE. NO ROTATION. RAINFALL DEPTH DECREASED 7%.

(3) HYPO-FLOOD OR-3: STORM OR 5-6, RAINFALL DEPTH DECREASED 1%.

(4) HYPO-FLOOD OR-4: STORM LMV 1-5, CENTER TRANSPOSED FROM MARION, KY. TO COLUMBUS, OHIO. STORM ROTATED 10° CLOCKWISE. RAINFALL DEPTH DECREASED 20%. STORM LMV 1-9, CENTER TRANSPOSED FROM NEW MADRID, MO. TO SAYLERSVILLE, KY. STORM ROTATED 4° CLOCKWISE. RAINFALL DEPTH DECREASED 8%. BARRIER DEPLETION ADJUSTMENT MADE FOR PORTION OF STORM TRANSPOSED INTO MOUNTAINS.

(5) HYPO-FLOOD OR-20: STORM OR 1-7, CENTER TRANSPOSED FROM CLARINGTON, OHIO, 150 MI. NE. STORM ROTATED 6° COUNTER-CLOCKWISE. RAINFALL DEPTH DECREASED 3%.

(6) HYPO-FLOOD OR-21: STORM OR 1-15, CENTER TRANSPOSED FROM BELLEFONTAINE, OHIO, 158 MI. E AND 43 MI. S. NO ROTATION. RAINFALL DEPTH INCREASED 2%. BARRIER DEPLETION ADJUSTMENT MADE TO SOUTH EAST PORTION OF TRANSPOSED STORM. STORM UMV 2-4, CENTER TRANSPOSED FROM WASHINGTON, IND., 200 MI. E-NE. NO ROTATION. RAINFALL DEPTH DECREASED 6%.

(7) HYPO-FLOOD OR-22A: STORM SA 1-27, NO TRANSPOSITION, OR ROTATION. RAINFALL DEPTH INCREASED 1% IN SECOND STORM.

LEGEND

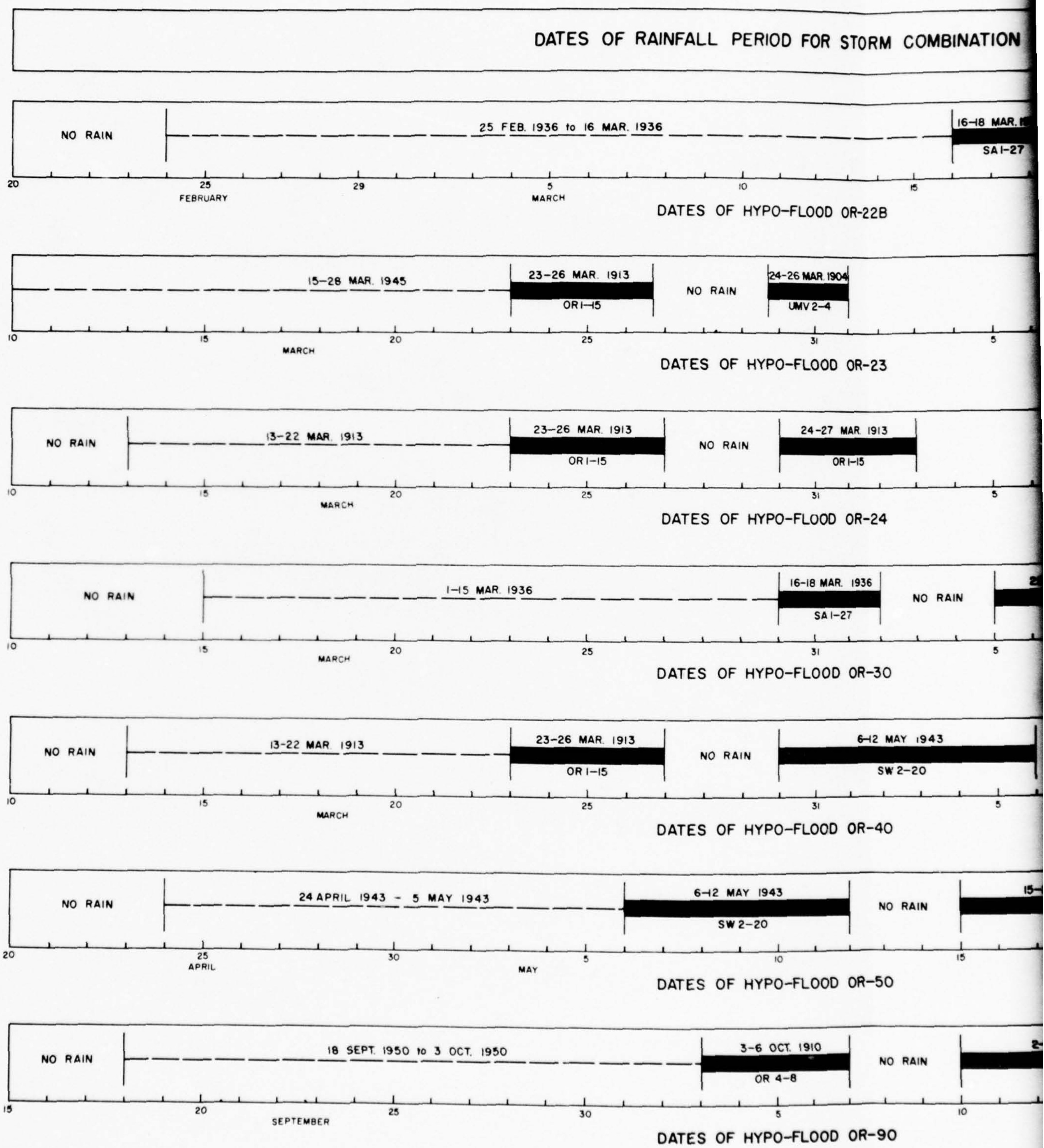
STORM RAINFALL

------ ANTECEDENT RAINFALL

2

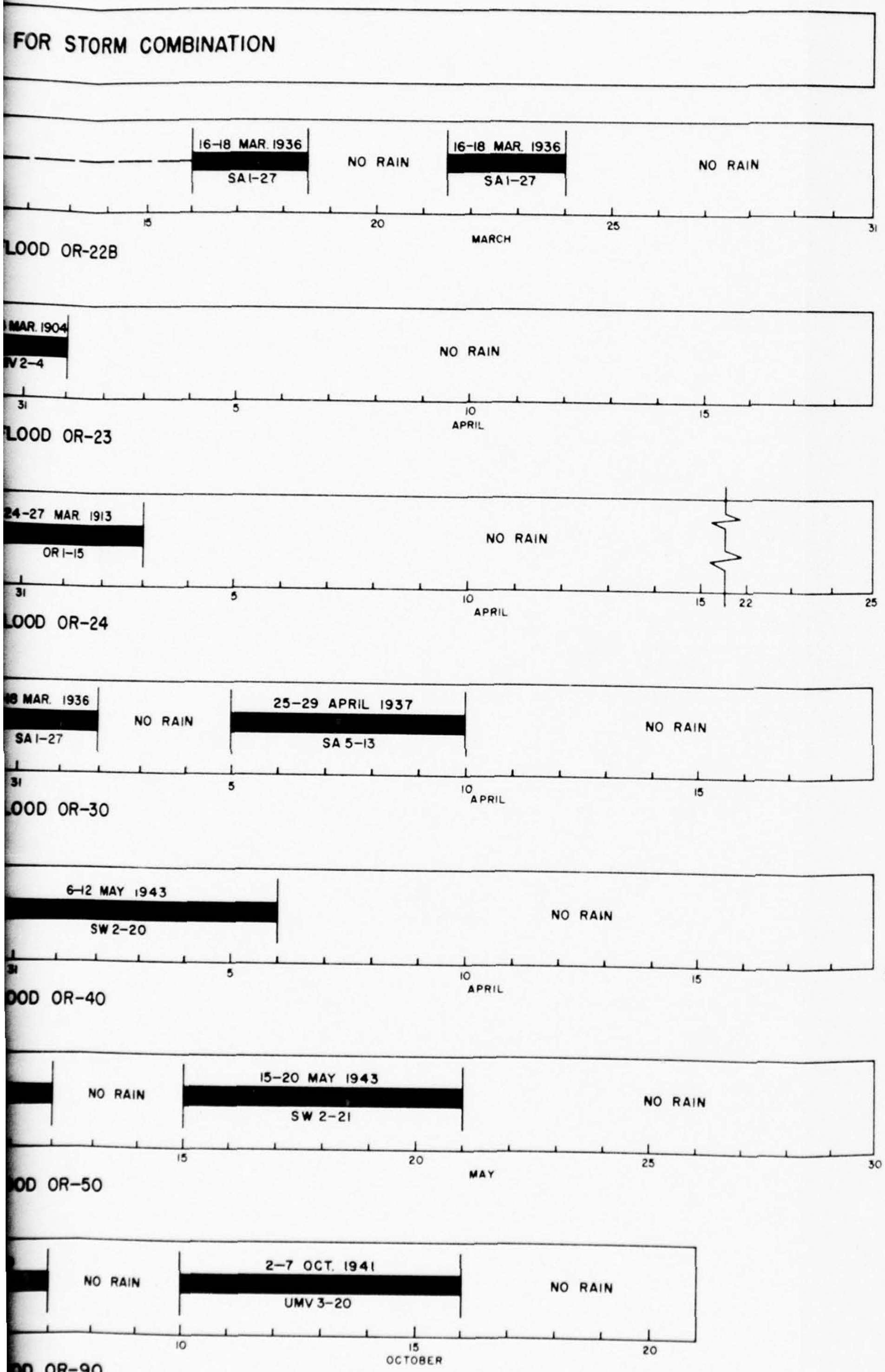
OHIO RIVER PROJECT FLOOD ST

RAINFALL PERIODS HYPOTHE



ER PROJECT FLOOD STUDY

S HYPOTHETICAL FLOODS



NOTES:

(1) HYPO-FLOOD OR-22B: STORM SA1-27, SECOND STORM, CENTER TRANSPOSED 100 MI. W. AND 40 MI. S. NO ROTATION. RAINFALL DEPTH INCREASED 8%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(2) HYPO-FLOOD OR-23: STORM UMV 2-4, CENTER TRANSPOSED FROM WASHINGTON, IND. TO HAZARD, KY. NO ROTATION. RAINFALL DEPTH INCREASED 3%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(3) HYPO-FLOOD OR-24: STORM OR 1-15, SECOND STORM, CENTER TRANSPOSED FROM BELLEFONTAINE, OHIO TO ATHENS, OHIO. STORM ROTATED 7° COUNTER-CLOCKWISE. RAINFALL DEPTH INCREASED 5%. BARRIER DEPLETION ADJUSTMENT MADE TO SOUTHEAST PORTION OF TRANSPOSED STORM.

(4) HYPO-FLOOD OR-30: STORM SA 1-27, CENTER TRANSPOSED 85 MI. W-NW. NO ROTATION OR RAINFALL ADJUSTMENT. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION. STORM SA 5-13, CENTER TRANSPOSED 135 MI. NW. NO ROTATION. RAINFALL DEPTH DECREASED 5%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(5) HYPO-FLOOD OR-40: STORM SW 2-20, CENTER TRANSPOSED FROM WARNER, OKLA. TO LOUISVILLE, KY. NO ROTATION. RAINFALL DEPTH DECREASED 14%.

(6) HYPO-FLOOD OR-50: STORM SW 2-20, CENTER TRANSPOSED FROM WARNER, OKLA. TO OLD HICKORY DAM, TENN. STORM ROTATED 5° CLOCKWISE. RAINFALL DEPTH DECREASED 5% BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION. STORM SW 2-21, CENTER TRANSPOSED FROM LOWELL, KAN. TO NASHVILLE, TENN. STORM ROTATED 5° COUNTER-CLOCKWISE. RAINFALL DEPTH INCREASED 1%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(7) HYPO-FLOOD OR-90: STORM OR 4-8, CENTER TRANSPOSED FROM GOLCONDA, ILL. TO BELLEFONTAINE, OHIO. STORM ROTATED 10° CLOCKWISE. RAINFALL DEPTH DECREASED 10%. STORM UMV 3-20, CENTER TRANSPOSED FROM GALESBURG, ILL. TO EDMONTON, KY. NO ROTATION. RAINFALL DEPTH INCREASED 10%.

LEGEND

STORM RAINFALL

——— ANTECEDENT RAINFALL

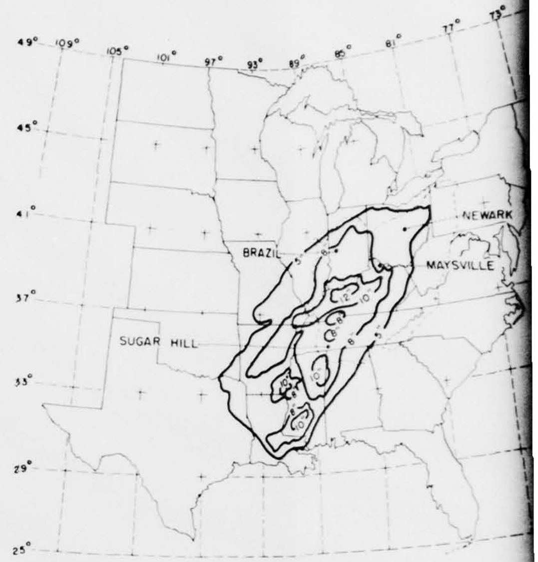
2

PLATE 34b

OHIO RIVER PROJECT FLOO
STORM DATA HYPO-FL
OR-1 AND OR-5A

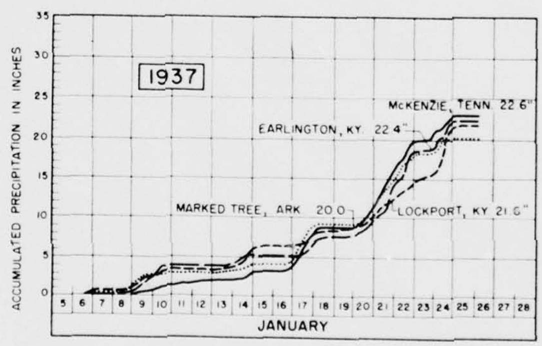
JANUARY 1937 transposed

NOTE: Storm OR 5-6 center at McKenzie, Tennessee, transposed 240miles East North East to Little Hickman, Kentuky. Barrier depletion adjustment made to rainfall No rotation of storm pattern. No adjustment made in rainfall depth.

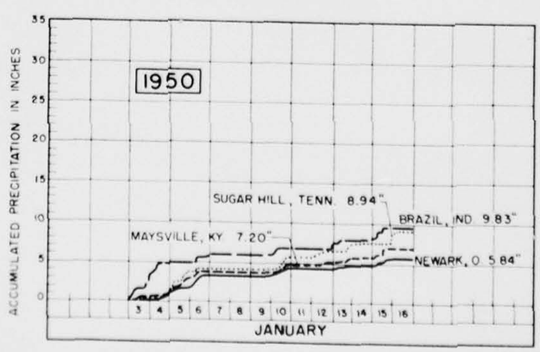


JANUARY 1950

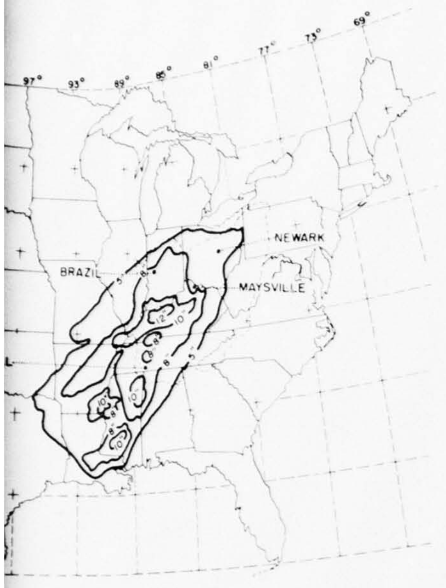
ISOHYETAL MAPS



MASS RAINFALL CURVES

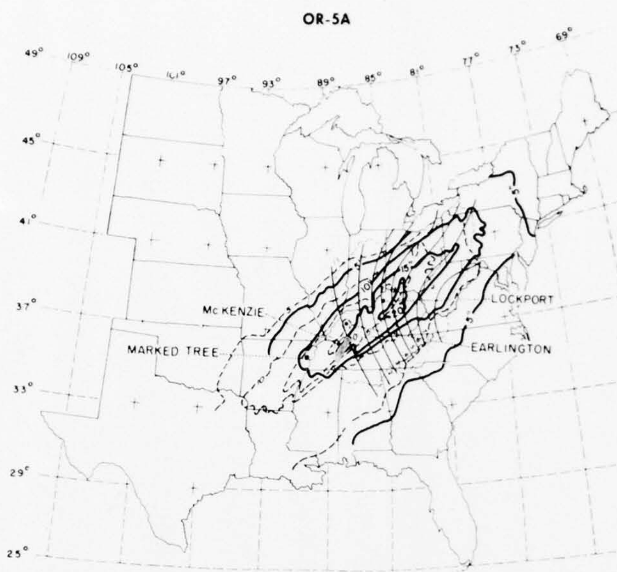


R PROJECT FLOOD STUDY
DATA HYPO-FLOODS
R-1 AND OR-5A



JANUARY 1950

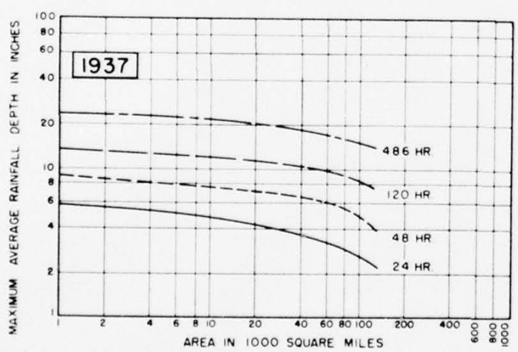
OR-5A



JANUARY 1937 transposed

NOTE: Storm OR 5-6 center at McKenzie, Tennessee, transposed 240miles East North East to Little Hickman, Kentucky. No rotation of storm pattern. Barrier depletion adjustment made to rainfall depths; Zone: 1-97%, 2-95%, 3-93%, 4-91%, 5-89%, 6-87%, 7-85%.

ISOHYETAL MAPS



AREA-DEPTH-DURATION CURVES

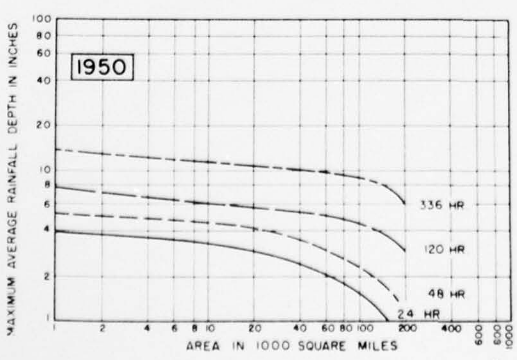
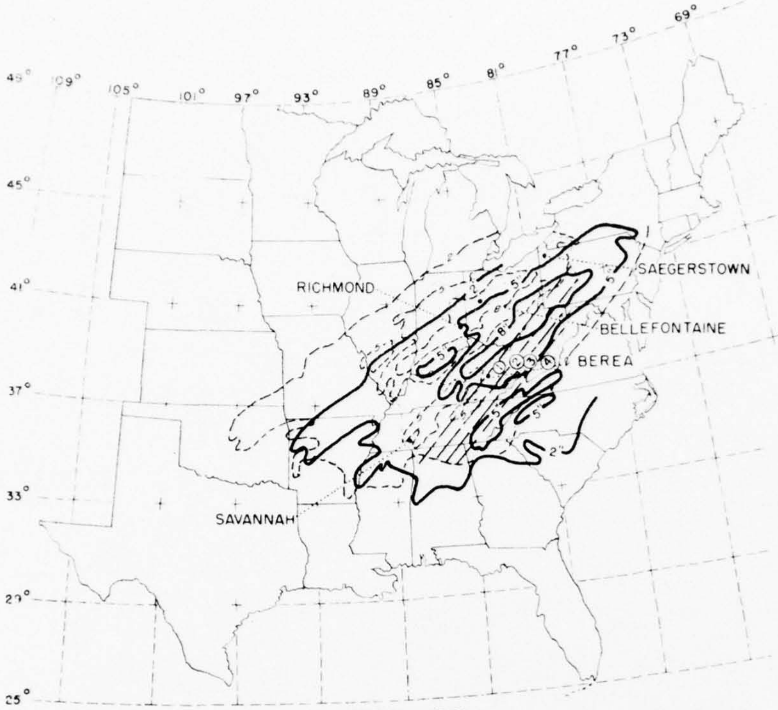


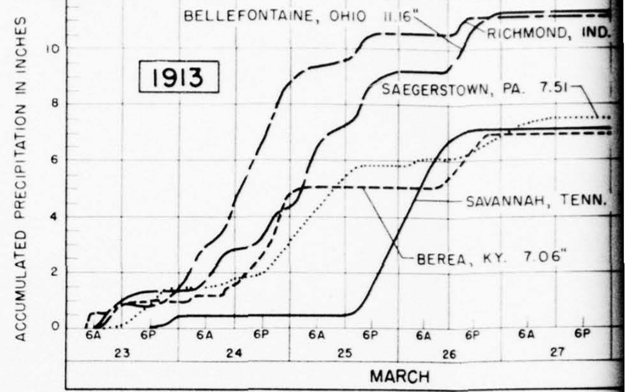
PLATE 35

2

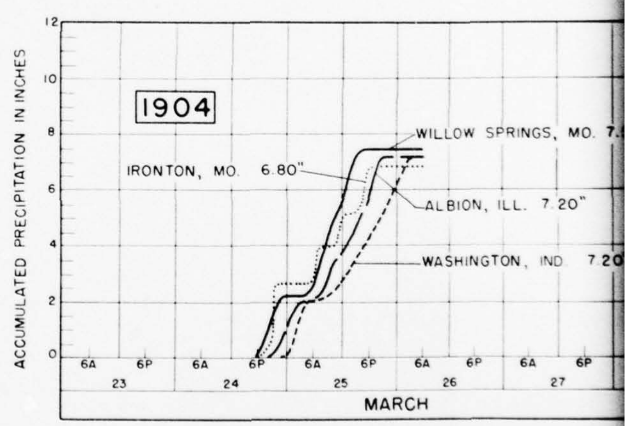
OHIO RIVER PROJECT FLOO
STORM DATA HYPO-FL



MARCH 1913
OR 1-15 TRANSPOSED



MARCH 1904
UMV 2-4 TRANSPOSED



MASS RAINFALL CURVES

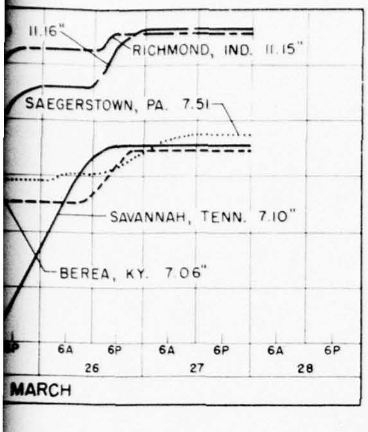
ISOHYETAL MAPS

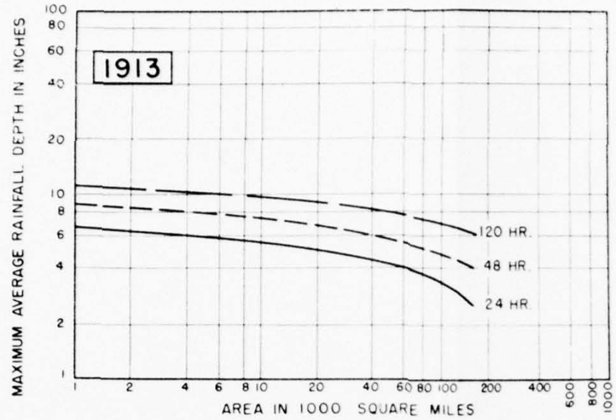
SCALE IN MILES
0 250 500

1

PROJECT FLOOD STUDY

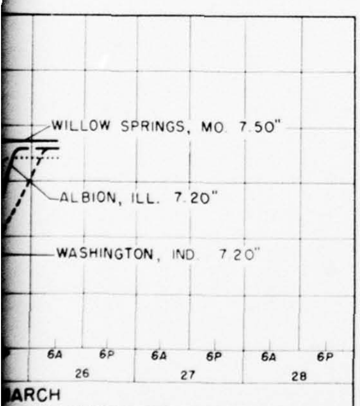
HYPO-FLOOD OR-21

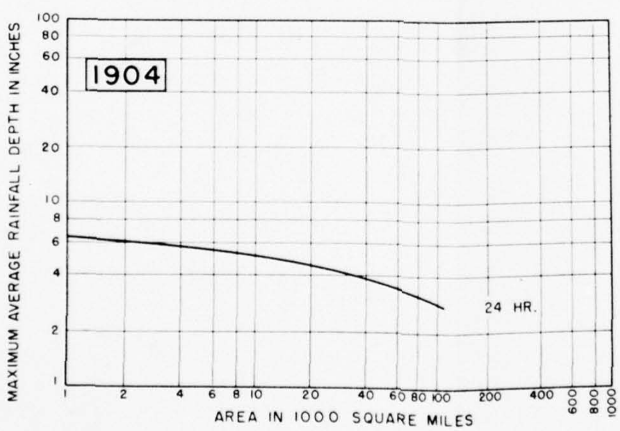




NOTE:

STORM OR 1-15 CENTER AT BELLEFONTAINE, OHIO, TRANSPOSED 158 MILES EAST AND 43 MILES SOUTH. NO ROTATION OF STORM PATTERN. RAINFALL DEPTH INCREASED 2%. BARRIER DEPLETION ADJUSTMENT MADE TO RAINFALL DEPTHS IN SOUTH EAST PORTION OF TRANSPOSED STORM, ZONE 1 – 93%, ZONE 2 – 91%, ZONE 3 – 86%, ZONE 4 – 82%.





NOTE:

STORM UMV 2-4 CENTER AT WASHINGTON, INDIANA, TRANSPOSED 200 MILES EAST NORTH EAST TO PEEBLES, OHIO. NO ROTATION OF STORM PATTERN. RAINFALL DEPTH DECREASED BY 6%.

FALL CURVES

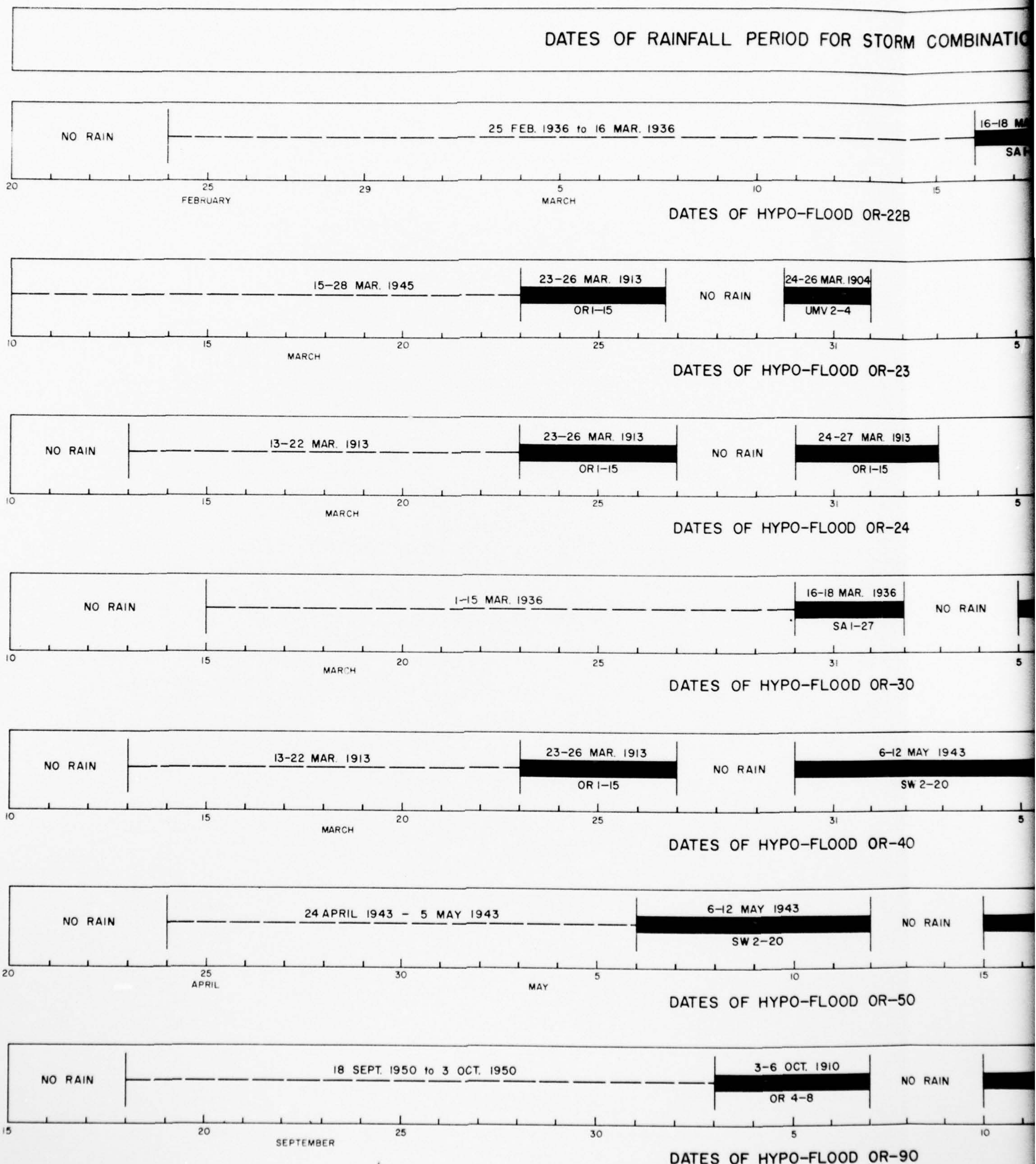
AREA-DEPTH-DURATION CURVES

PLATE 36a

2

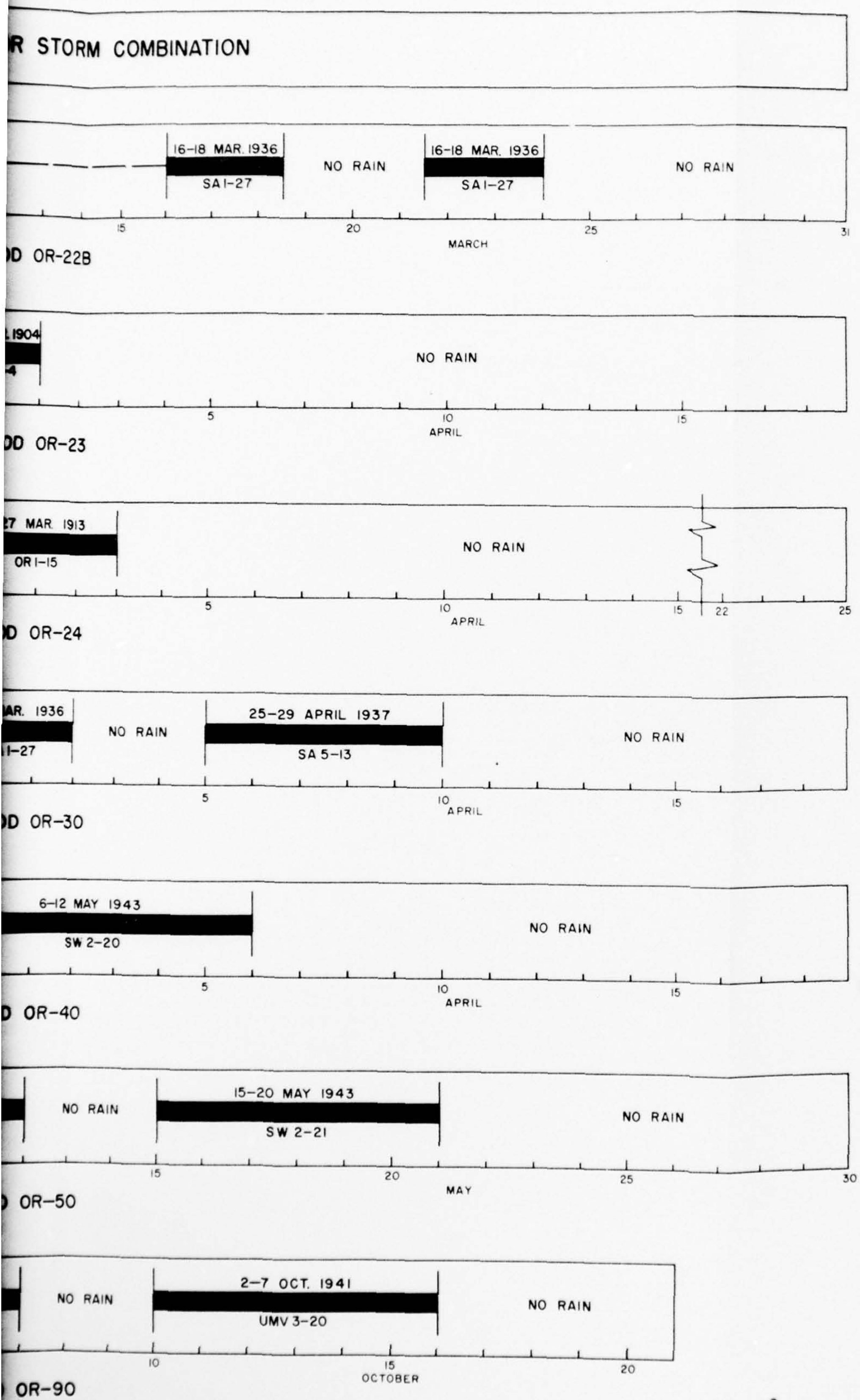
OHIO RIVER PROJECT FLOOD

RAINFALL PERIODS – HYPOTH



PROJECT FLOOD STUDY

– HYPOTHETICAL FLOODS



NOTES:

(1) HYPO-FLOOD OR-22B: STORM SA1-27 SECOND STORM, CENTER TRANSPOSED 100 MI. W. AND 40 MI. S. NO ROTATION. RAINFALL DEPTH INCREASED 8%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(2) HYPO-FLOOD OR-23: STORM UMV 2-4, CENTER TRANSPOSED FROM WASHINGTON, IND. TO HAZARD, KY. NO ROTATION. RAINFALL DEPTH INCREASED 3%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(3) HYPO-FLOOD OR-24: STORM OR 1-15 SECOND STORM, CENTER TRANSPOSED FROM BELLEFONTAINE, OHIO TO ATHENS, OHIO. STORM ROTATED 7° COUNTER-CLOCKWISE. RAINFALL DEPTH INCREASED 5%. BARRIER DEPLETION ADJUSTMENT MADE TO SOUTHEAST PORTION OF TRANSPOSED STORM.

(4) HYPO-FLOOD OR-30: STORM SA 1-27, CENTER TRANSPOSED 85 MI. W-NW. NO ROTATION OR RAINFALL ADJUSTMENT. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION. STORM SA 5-13, CENTER TRANSPOSED 135 MI. NW. NO ROTATION. RAINFALL DEPTH DECREASED 5%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(5) HYPO-FLOOD OR-40: STORM SW 2-20 CENTER TRANSPOSED FROM WARNER, OKLA. TO LOUISVILLE, KY. NO ROTATION. RAINFALL DEPTH DECREASED 14%.

(6) HYPO-FLOOD OR-50: STORM SW 2-20, CENTER TRANSPOSED FROM WARNER, OKLA. TO OLD HICKORY DAM, TENN. STORM ROTATED 5° CLOCKWISE. RAINFALL DEPTH DECREASED 5% BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION. STORM SW 2-21, CENTER TRANSPOSED FROM LOWELL, KAN. TO NASHVILLE, TENN. STORM ROTATED 5° COUNTER-CLOCKWISE. RAINFALL DEPTH INCREASED 1%. BARRIER DEPLETION ADJUSTMENT IS MADE FOR TRANSPOSITION.

(7) HYPO-FLOOD OR-90: STORM OR 4-8, CENTER TRANSPOSED FROM GOLCONDA, ILL. TO BELLEFONTAINE, OHIO. STORM ROTATED 10° CLOCKWISE. RAINFALL DEPTH DECREASED 10%. STORM UMV 3-20, CENTER TRANSPOSED FROM GALESBURG, ILL. TO EDMONTON, KY. NO ROTATION. RAINFALL DEPTH INCREASED 10%.

LEGEND

▬▬▬ STORM RAINFALL

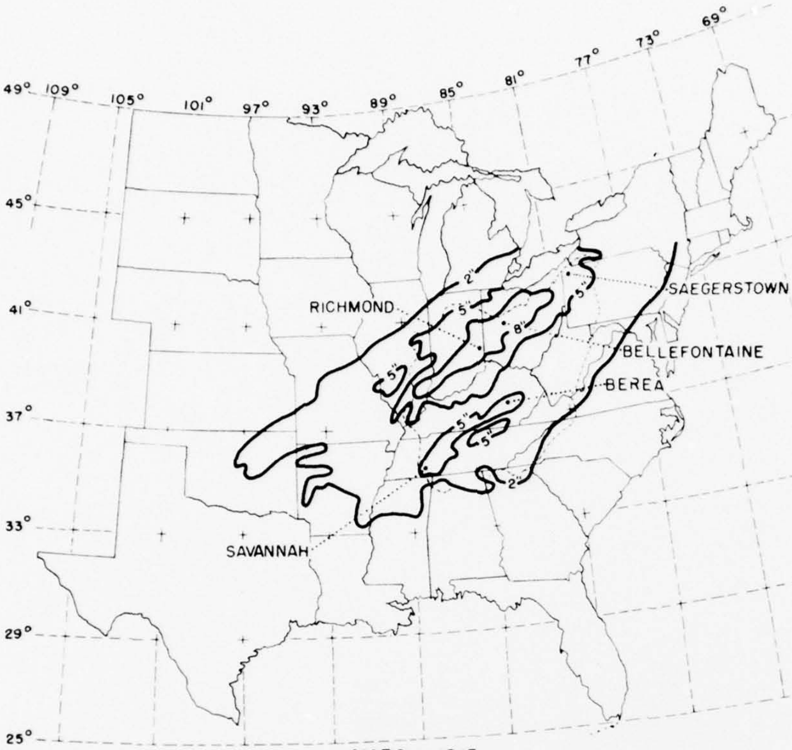
– – – – ANTECEDENT RAINFALL

PLATE 36b

2

OHIO RIVER PROJECT FLOOD STU

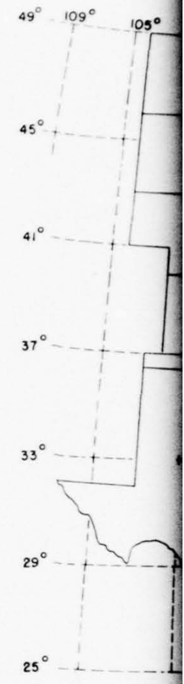
STORM DATA HYPO-FLOO

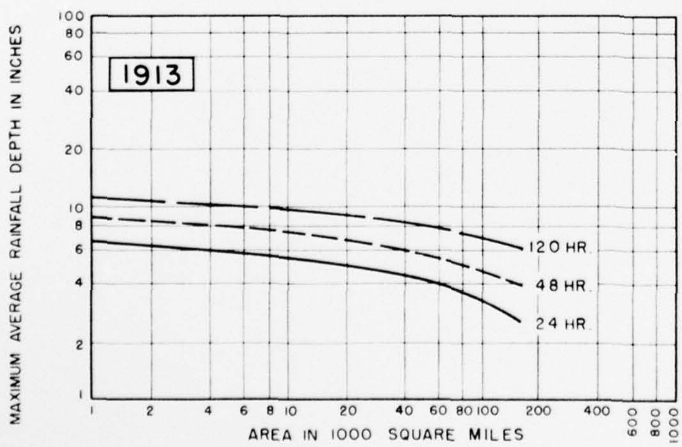


MARCH 1913
OR 1—15

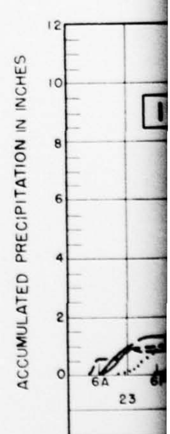
ISOHYETAL MAP

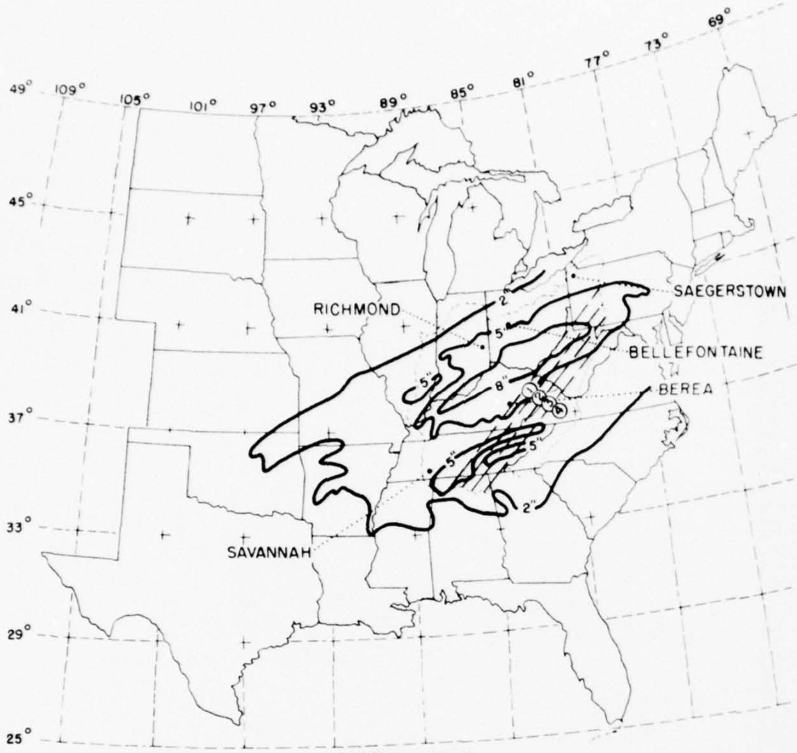
SCALE IN MILES
0 250 500





AREA-DEPTH-DURATION CURVE



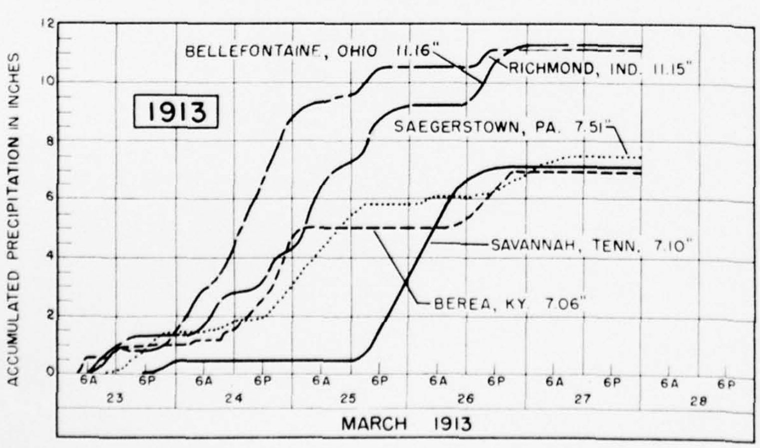


NOTE:

STORM OR I-15 CENTER AT BELLEFONTAINE, OHIO, TRANSPOSED 115 MILES SOUTH EAST TO ATHENS, OHIO. STORM PATTERN ROTATED 7° COUNTER-CLOCKWISE. RAINFALL DEPTH INCREASED 5%. BARRIER DEPLETION ADJUSTMENT MADE TO RAINFALL DEPTH IN SOUTH EAST PORTION OF TRANSPOSED STORM; ZONE 1-93%, ZONE 2-91%, ZONE 3-86%, ZONE 4-82%.

MARCH 1913
OR I-15 TRANSPOSED
ISOHYETAL MAP

SCALE IN MILES
0 250 500



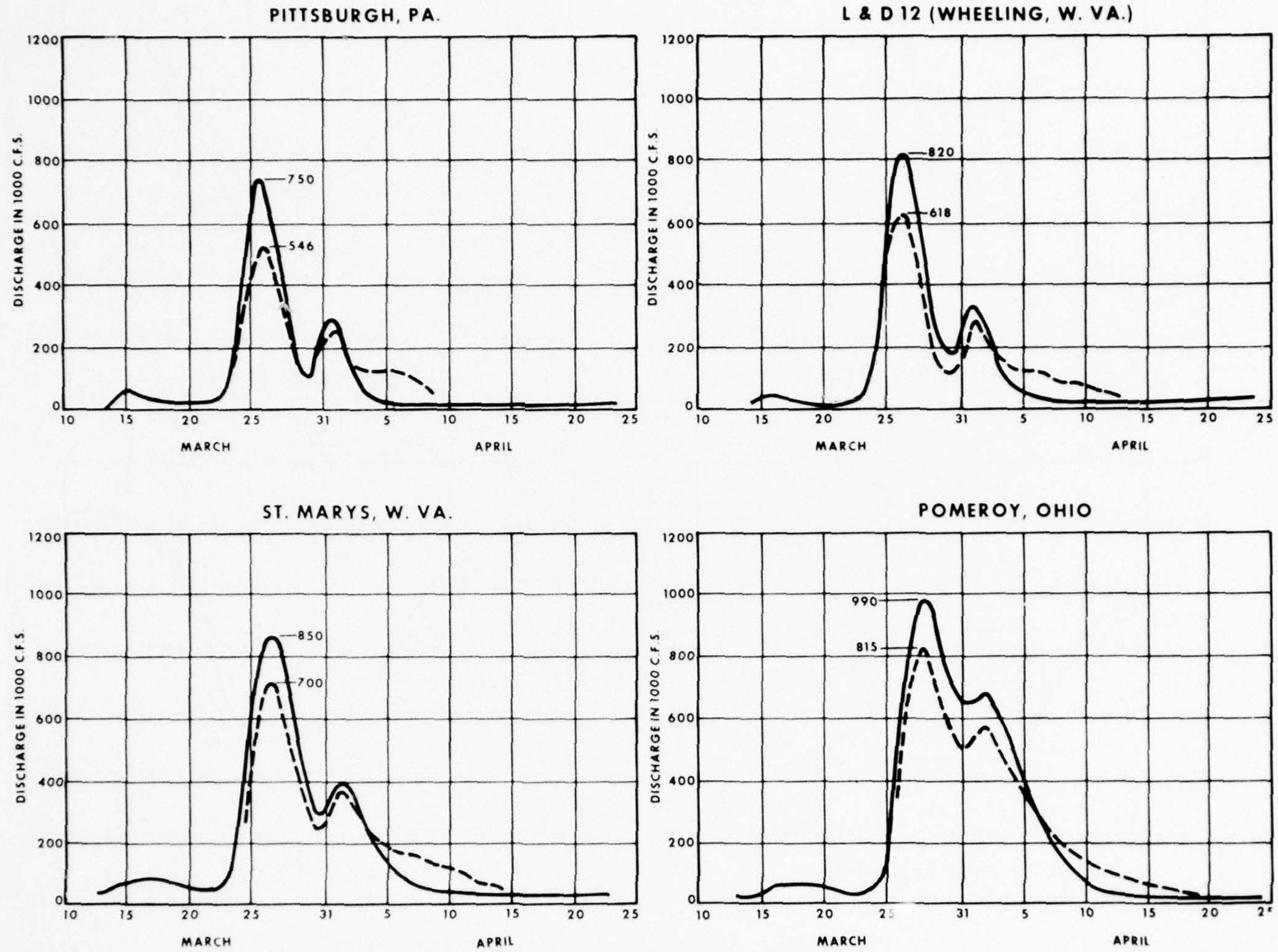
MASS RAINFALL CURVES

PLATE 37

2

OHIO RIVER PROJECT FLOOD STUDY

DISCHARGE HYDROGRAPHS
STANDARD PROJECT FLOOD



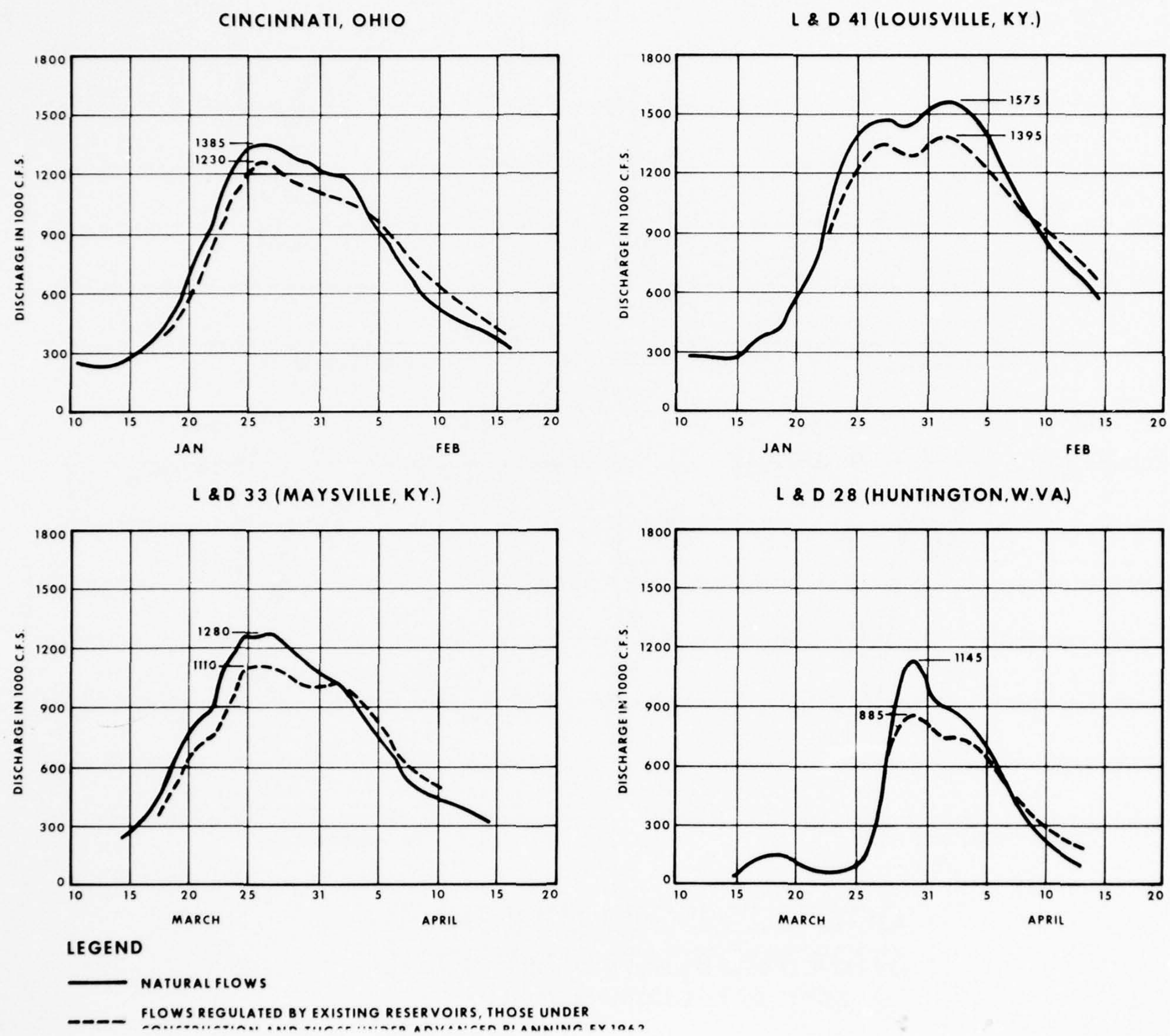
LEGEND

——— NATURAL FLO

– – – – FLOWS REGULATED BY EXISTING RESERVOIRS, THOSE UNDER CONSTRUCTION AND THOSE UNDER ADVANCED PLANNING FY 1963

OHIO RIVER PROJECT FLOOD STUDY

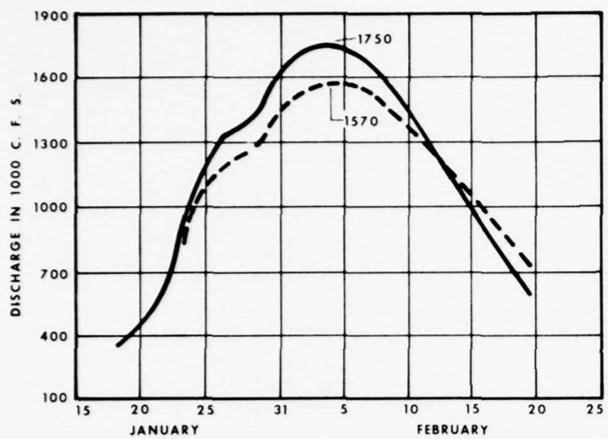
DISCHARGE HYDROGRAPHS
STANDARD PROJECT FLOOD



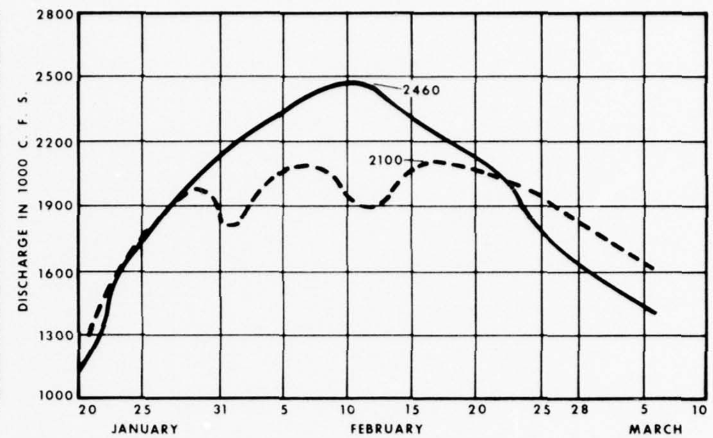
OHIO RIVER PROJECT FLOOD STUDY

DISCHARGE HYDROGRAPHS
STANDARD PROJECT FLOOD

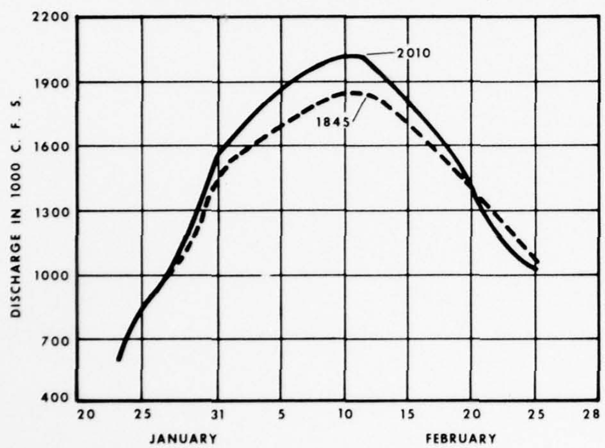
EVANSVILLE, IND



L & D 52 (METROPOLIS, ILL.)



L & D. 51 (GOLCONDA, ILL.)

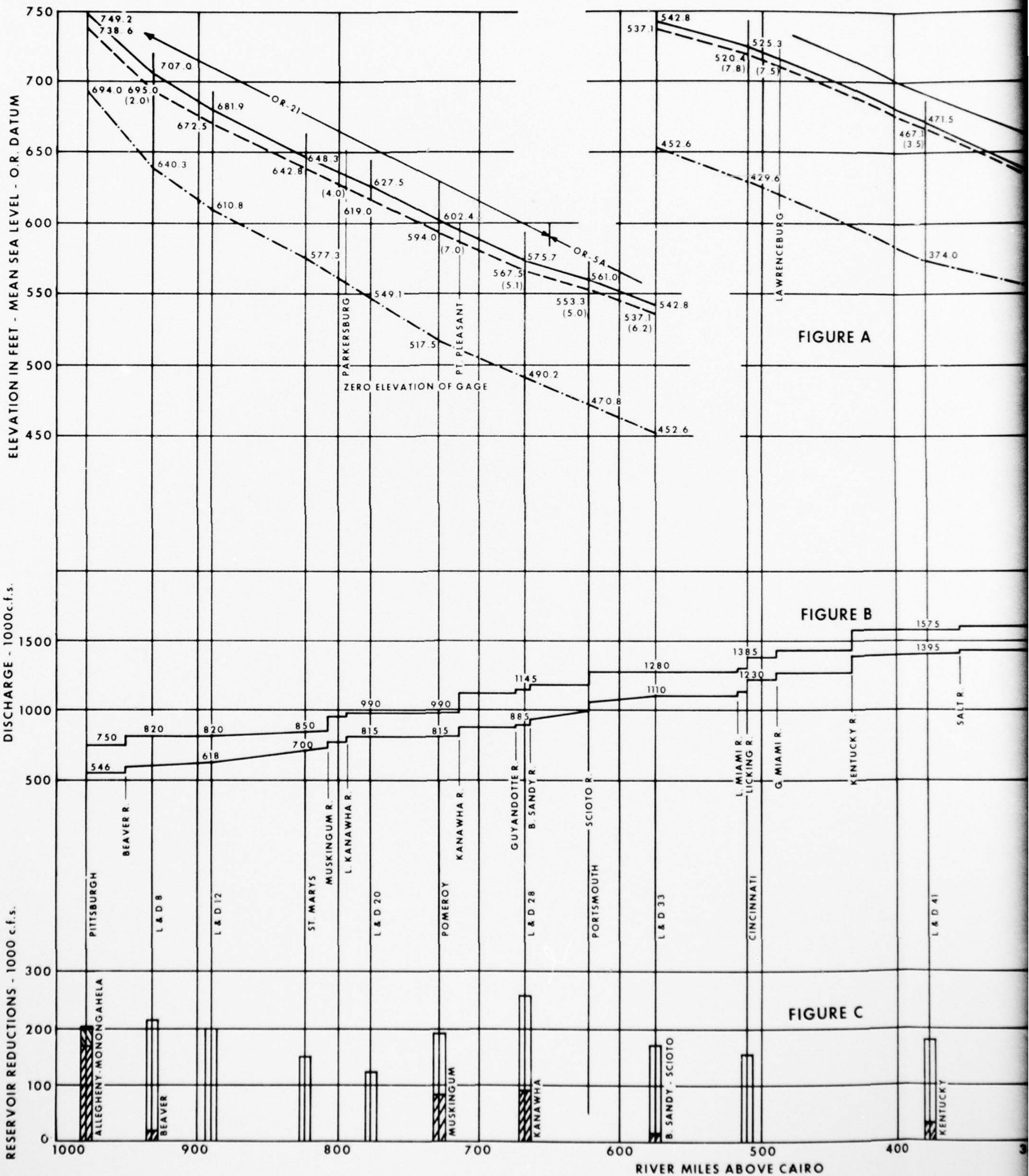


LEGEND

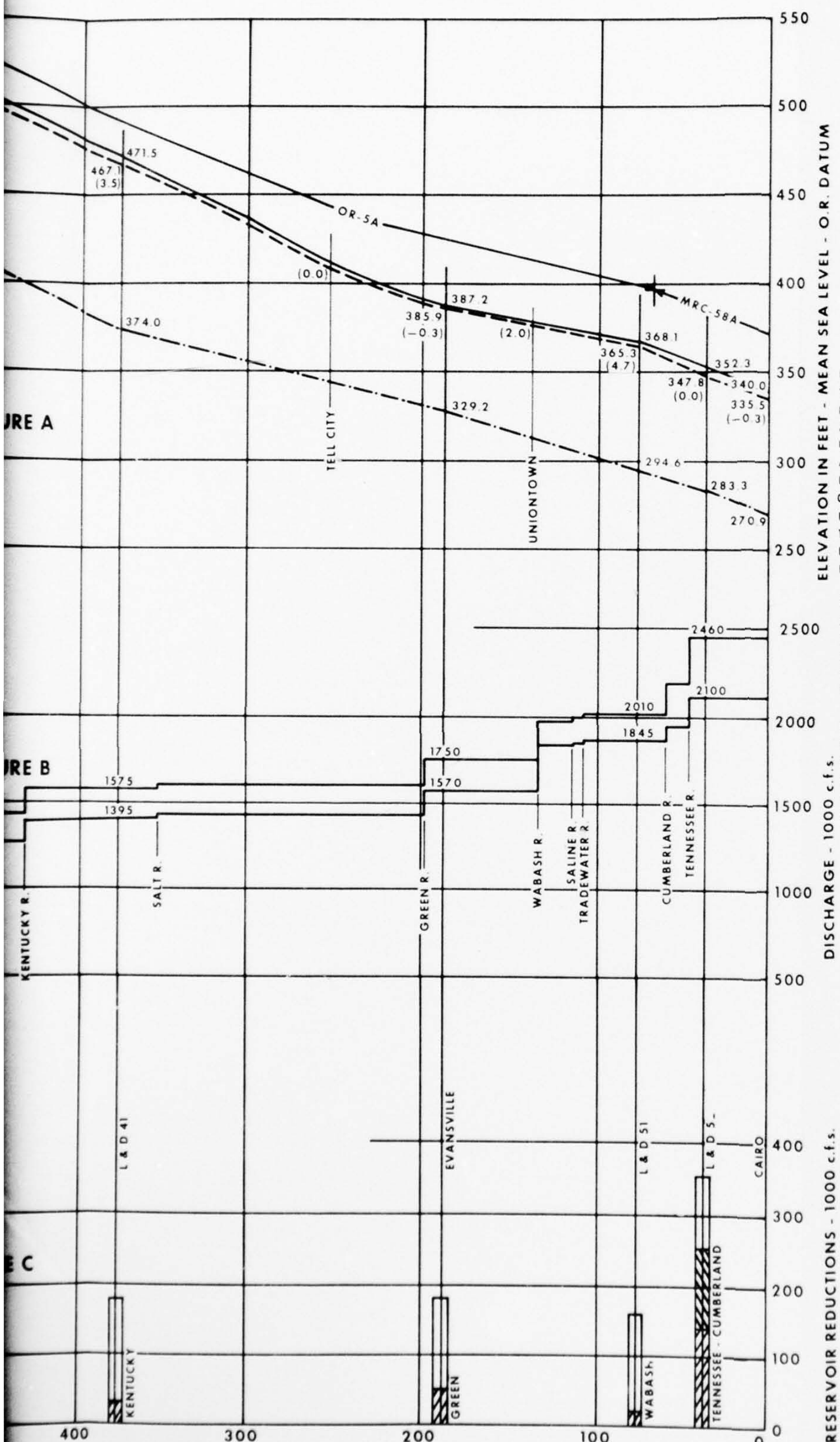
—— NATURAL FLOWS

- - - FLOWS REGULATED BY EXISTING RESERVOIRS, THOSE UNDER CONSTRUCTION AND THOSE UNDER ADVANCED PLANNING FY 1963

OHIO RIVER PROJECT FL
STANDARD PROJEC
NATURAL AND REGULATE



ER PROJECT FLOOD STUDY
RD PROJECT FLOOD
REGULATED CONDITIONS



NOTES:

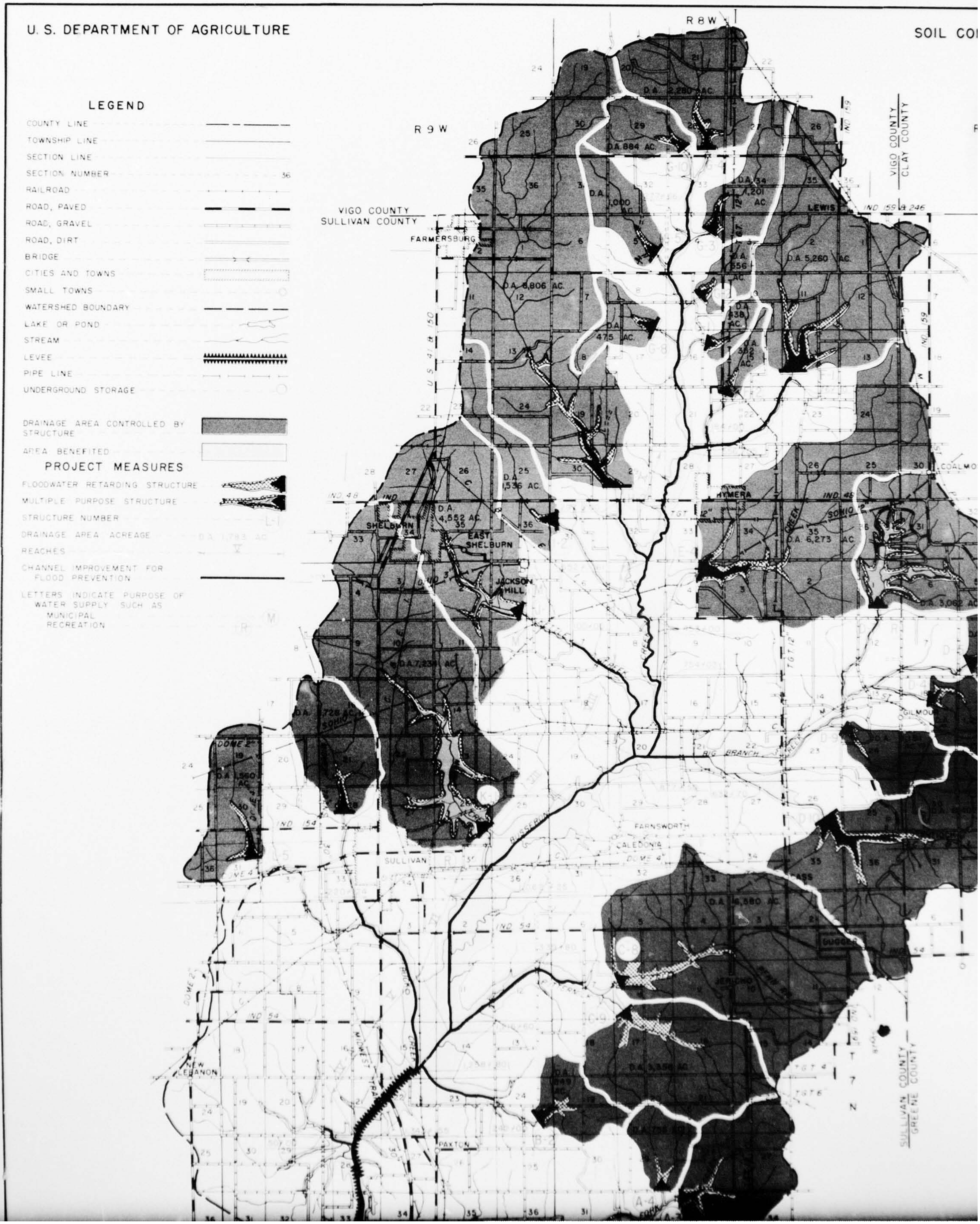
1. FIGURE A. PROFILE. WATER SURFACE ELEVATION GIVEN IN FEET ABOVE MEAN SEA LEVEL FOR NATURAL FLOWS AND FOR FLOWS REGULATED BY RESERVOIRS COMPLETED, UNDER CONSTRUCTION, AND IN ADVANCED PLANNING AS OF 1 JULY 1963. THE VALUE IN PARENTHESES AT SPECIFIC LOCATIONS IS THE DIFFERENCE IN FEET BETWEEN THE TOP OF THE LOCAL PROTECTION WORKS AND THE REGULATED FLOOD CREST. (A NEGATIVE VALUE INDICATES THAT THE REGULATED FLOOD CREST IS BELOW THE PROTECTION ELEVATION.) THE LIMITS OF THE SELECTED HYPOTHETICAL FLOODS (OR-21, OR-5A, AND MRC-58A) ARE SHOW.

2. FIGURE B. PEAK DISCHARGES. VALUES SHOWN ARE THE PEAK DISCHARGES FOR NATURAL AND REGULATED CONDITIONS AT KEY LOCATIONS. LOCATION OF JUNCTION OF EACH MAIN TRIBUTARY IS SHOWN WITH ESTIMATED INCREASE IN FLOW AT JUNCTION INDICATED.

3. FIGURE C. RESERVOIR REDUCTIONS. BAR CHARTS REPRESENT AMOUNT OF CREST FLOW REDUCTION AT KEY LOCATIONS. SHADED AREAS REPRESENT THE PROPORTION OF THE REDUCTION ATTRIBUTABLE TO TRIBUTARY SYSTEMS AT THE FIRST KEY LOCATION DOWNSTREAM FROM THE TRIBUTARY JUNCTION.

2

PLATE 39


U. S. DEPARTMENT OF AGRICULTURE
SOIL CO
LEGEND
COUNTY LINE
TOWNSHIP LINE
SECTION LINE
SECTION NUMBER
RAILROAD
ROAD, PAVED
ROAD, GRAVEL
ROAD, DIRT
BRIDGE
CITIES AND TOWNS
SMALL TOWNS
WATERSHED BOUNDARY
LAKE OR POND
STREAM
LEVEE
PIPE LINE
UNDERGROUND STORAGE
DRAINAGE AREA CONTROLLED BY STRUCTURE
AREA BENEFITED
PROJECT MEASURES
FLOODWATER RETARDING STRUCTURE
MULTIPLE PURPOSE STRUCTURE
STRUCTURE NUMBER
DRAINAGE AREA ACREAGE
REACHES
CHANNEL IMPROVEMENT FOR FLOOD PREVENTION
LETTERS INDICATE PURPOSE OF WATER SUPPLY SUCH AS MUNICIPAL RECREATION
R 8 W
R 9 W
VIGO COUNTY
SULLIVAN COUNTY
VIGO COUNTY
CLAY COUNTY
SULLIVAN COUNTY
GREENE COUNTY
FARMERSBURG
SHELBURN
EAST SHELBURN
JACKSON HILL
HYMERA
LEWIS
COALMO
GILMOU
SULLIVAN
FARNSWORTH
CALEDONIA
DUGGER
JERICHO
NEW LEBANON
PAXTON
CASS
D.A. 2,280 AC.
D.A. 884 AC.
D.A. 1,000 AC.
D.A. 1,201 AC.
D.A. 5,260 AC.
D.A. 5,806 AC.
D.A. 475 AC.
D.A. 1,536 AC.
D.A. 4,552 AC.
D.A. 6,273 AC.
D.A. 3,062 AC
D.A. 7,230 AC.
D.A. 1,560 AC.
D.A. 6,380 AC.
BIG BRANCH
T 7 N

AD-A041 272 F/G 8/6

OHIO RIVER BASIN COMPREHENSIVE SURVEY. VOLUME IV. APPENDIX C. H--ETC(U)

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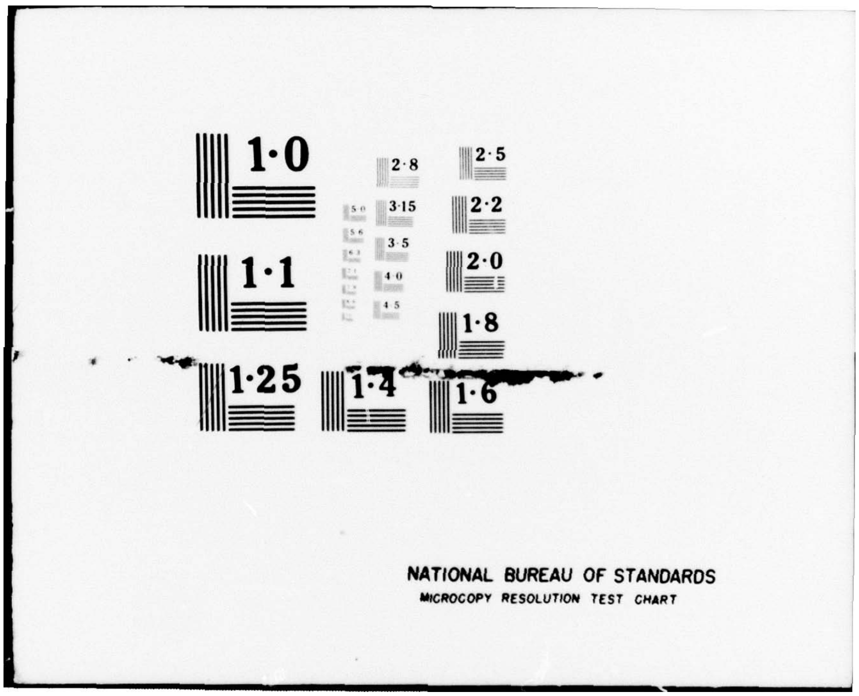
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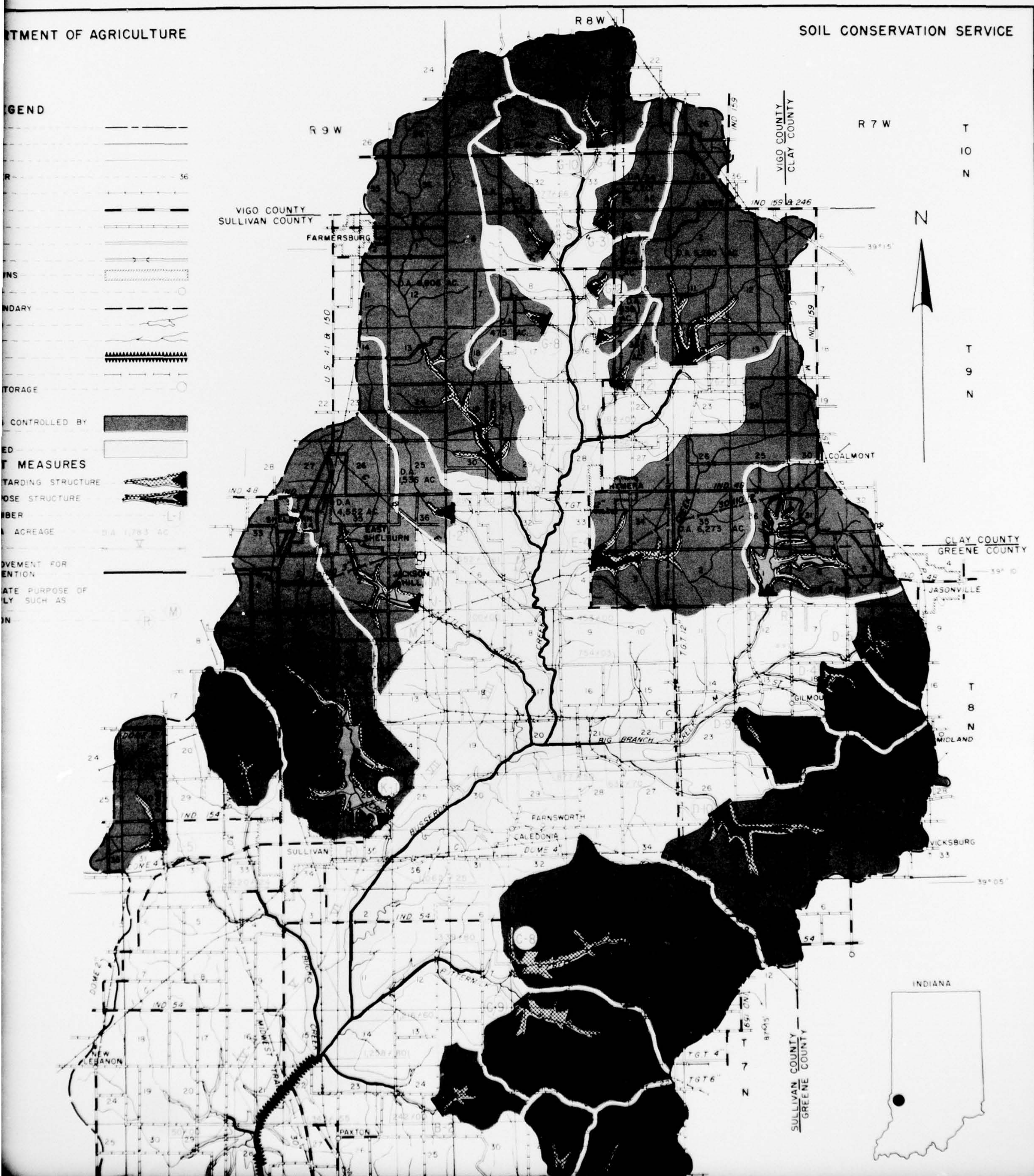
4·5
NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

2



RTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
GEND
TARDING STRUCTURE
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R8W
R9W
R7W
T 10 N
T 9 N
T 8 N
T 7 N
VIGO COUNTY
SULLIVAN COUNTY
VIGO COUNTY
CLAY COUNTY
CLAY COUNTY
GREENE COUNTY
SULLIVAN COUNTY
GREENE COUNTY
FARMERSBURG
COALMONT
JASONVILLE
MIDLAND
VICKSBURG
EAST SHELBURN
JACKSONVILLE
FARNSWORTH
CALEDONIA
SULLIVAN
NEW LEBANON
PAXTON
BIG BRANCH
D.A. 1,536 AC.
D.A. 4,552 AC.
D.A. 6,273 AC.
IND 48
IND 54
IND 154
IND 159
IND 159 & 246
U S 41 & 150
39°15'
39°10'
39°05'
N
INDIANA

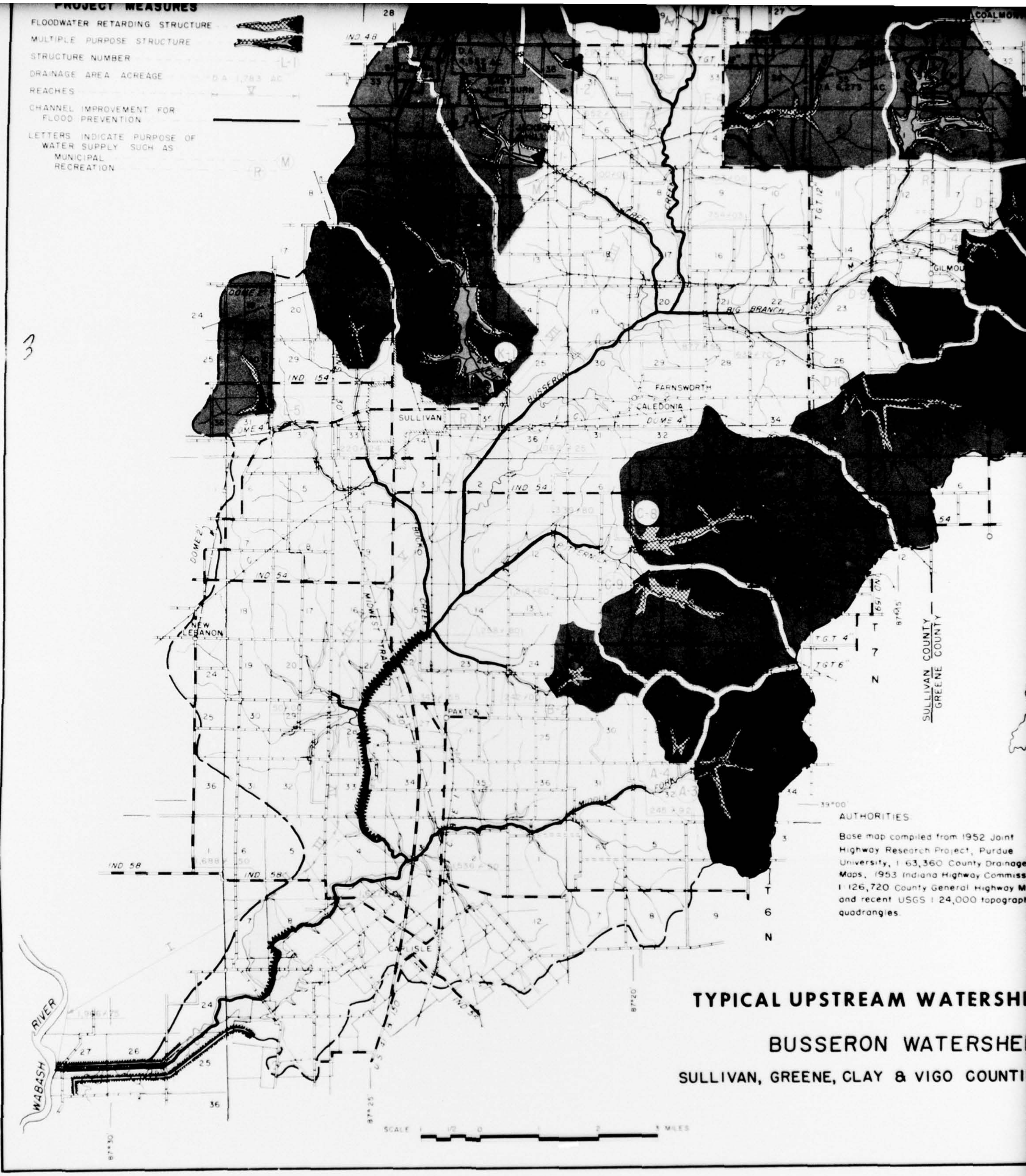
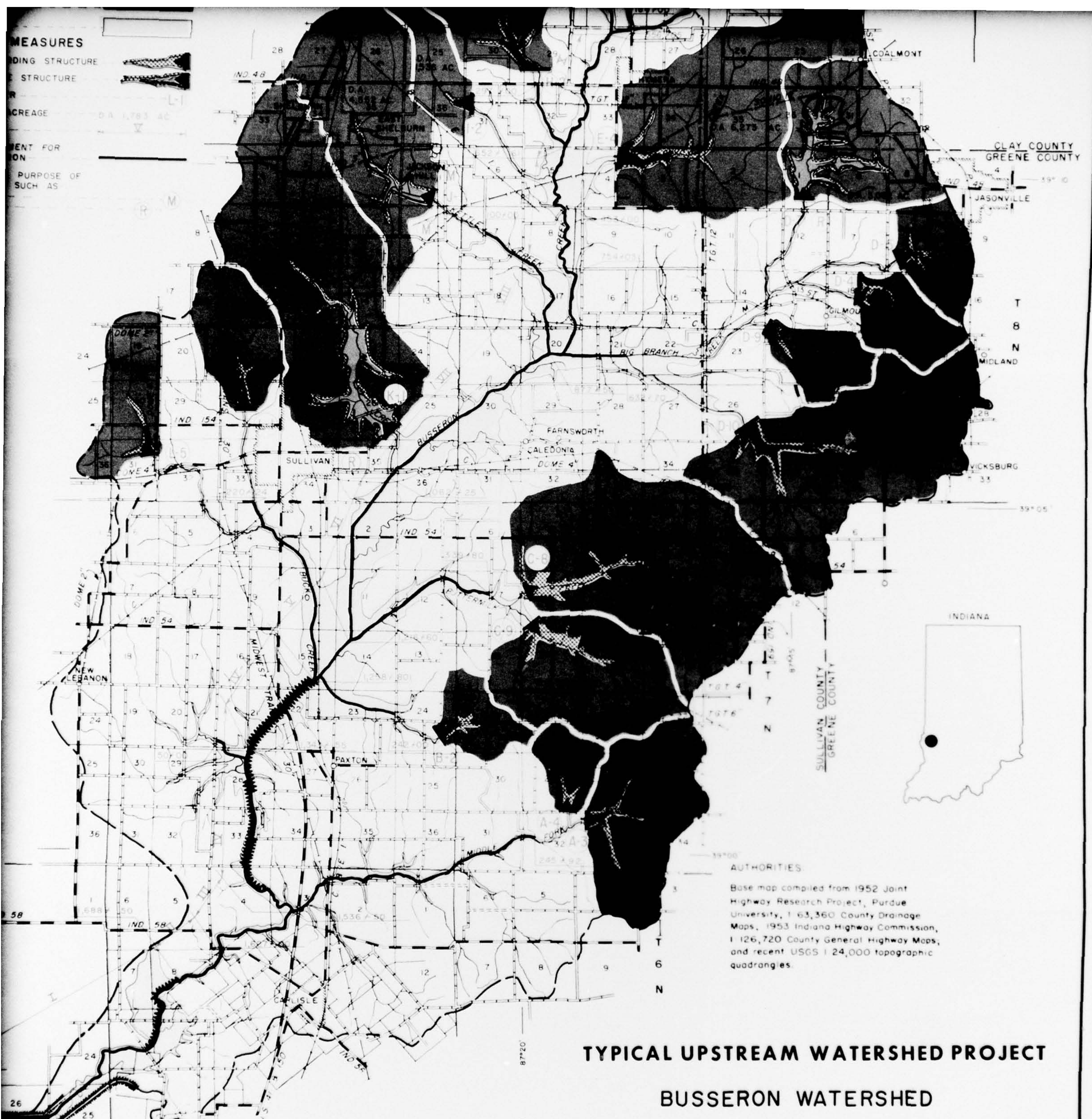

PROJECT MEASURES
FLOODWATER RETARDING STRUCTURE
MULTIPLE PURPOSE STRUCTURE
STRUCTURE NUMBER
DRAINAGE AREA ACREAGE
REACHES
CHANNEL IMPROVEMENT FOR FLOOD PREVENTION
LETTERS INDICATE PURPOSE OF WATER SUPPLY SUCH AS MUNICIPAL RECREATION
SULLIVAN
FARNSWORTH
CALEDONIA
NEW LEBANON
PAXTON
CARLISLE
BIG BRANCH
BUSSERON
WABASH RIVER
SULLIVAN COUNTY
GREENE COUNTY
AUTHORITIES
Base map compiled from 1952 Joint Highway Research Project, Purdue University, 1:63,360 County Drainage Maps, 1953 Indiana Highway Commissio 1:126,720 County General Highway Ma and recent USGS 1:24,000 topographi quadrangles.
TYPICAL UPSTREAM WATERSHE
BUSSERON WATERSHED
SULLIVAN, GREENE, CLAY & VIGO COUNTIE
SCALE 1 1/2 0 1 2 3 MILES

PLATE 40

3

4


MEASURES
DING STRUCTURE
STRUCTURE
CREAGE
D.A. 1,783 AC.
ENT FOR
ON
PURPOSE OF
SUCH AS
CLAY COUNTY
GREENE COUNTY
COALMONT
JASONVILLE
MIDLAND
VICKSBURG
GILMOUR
BIG BRANCH
FARNSWORTH
CALEDONIA
SULLIVAN
BUSSERON
PAXTON
NEW LEBANON
CARLISLE
MIDWEST
SULLIVAN COUNTY
GREENE COUNTY
INDIANA
AUTHORITIES:
Base map compiled from 1952 Joint Highway Research Project, Purdue University, 1:63,360 County Drainage Maps, 1953 Indiana Highway Commission, 1:126,720 County General Highway Maps, and recent USGS 1:24,000 topographic quadrangles.
TYPICAL UPSTREAM WATERSHED PROJECT
BUSSERON WATERSHED
SULLIVAN, GREENE, CLAY & VIGO COUNTIES, INDIANA
SCALE 1 1/2 0 1 2 3 MILES
5-20-65
5 S-20,875-A