

CONCLUSIONS

Pollution Sources

During the field investigation 45 possible sources of acid mine drainage pollution were located. Of the sources located in the East Branch Clarion River Watershed, 33 were found to contribute acid discharges into tributary streams. Five of the pollution sources, Areas 3, 11, 12, 14 and 21 in the Swamp Creek and Johnson Run sub-basins, were responsible for over two-thirds of the total estimated average daily acid load for the year 1969.

Table 1, presents the sources arranged according to the percentage of total acid load contributed by each source in the East Branch Clarion River Watershed, based on the water quality tests performed over a one year period in 1968-69.

The 33 pollution sources were found to contribute on the average 5, 600 lbs. of acid per day into the tributary streams of the East Branch Clarion River. There are no significant sources of pollution on the main branch of the East Branch Clarion River.

Most of the acid mine drainage pollution is derived from sources within the drainage areas of two tributary streams. Swamp Creek and Johnson Run account for about 4, 800 lbs. per day of the total acid load. Four other tributary streams have significant sources of acid mine drainage pollution within their drainage areas and they are Yonkers Run, Borgardy Run, Twomile Run and Gum Boot Run. These four sub-basins account for about 705 lbs. per day of the acid load. One tributary stream, Smith Run, only has one source of pollution, the Anderson Mine, located in the headwaters, which has an average acid discharge of about 20 lbs. per day. It appears this small acid discharge is neutralized by alkaline discharges from branches of Smith Run farther downstream.

Table 2 shows the estimated average daily acid mine drainage pollution in lbs. per day attributed to sources within each of the sub-basins. Since many of the pollution sources are on topographic highs, some of them are along the drainage divides and, therefore, contribute pollution to more than one sub-basin.

TABLE 1

PERCENT OF TOTAL AVERAGE DAILY ACID LOAD
 CONTRIBUTED BY EACH POLLUTION SOURCE IN THE
 EAST BRANCH CLARION RIVER WATERSHED

<u>Pollution Source</u>	<u>Average Daily Acid Load lbs. per day</u>	<u>Percent of Total Acid Load</u>
Area 12	900	16.2
Areas 3 & 4	860	15.4
Area 14	830	14.9
Area 11	740	13.3
Area 21	450	8.1
Area 43	225	4.0
Area 10	215	3.8
Area 16	150	2.7
Area 24	150	2.7
Area 42	130	2.3
Area 6	120	2.2
Area 28	100	1.8
Area 5	90	1.6
Area 7	90	1.6
Area 8	90	1.6
Area 22	90	1.6
Area 9	60	1.1
Areas 1 & 2	50	0.9
Area 15	45	0.8
Area 25	40	0.7
Area 29	40	0.7
Area 20	20	0.4
Area 45	20	0.4
Area 23	10	0.2
Area 27	10	0.2
Area 30	10	0.2
Area 32	10	0.2
Area 34	10	0.2
Area 17	5	0.1
Area 26	5	0.1
Area 31	3	0.05
Area 13	0	0.0
Area 18	0	0.0
Area 19	0	0.0
Area 33	0	0.0
Area 36	0	0.0
Area 37	0	0.0
Area 44	0	0.0
Area 46	0	0.0
	<u>5,568</u>	<u>100.0</u>

TABLE 2

ESTIMATED AVERAGE DAILY
ACID MINE DRAINAGE POLLUTION
(Pounds per Day)

Source of Pollution	Main Stream East Branch Clarion River	West Branch Swamp Creek	East Branch Swamp Creek	Borgardy Run	Yonkers Run	Smith Run	Johnson Run	Twomile Run	Gum Boot Run	Fivemile Run	Sevenmile Run	Potato Creek	TOTAL
1			35										35*
2			15										15
3		850											850
4		10											10
5		90											90
6		60	60										120
7		45	45										90
8		10					80						90
9		30					30						60
10		15					200						215
11		30	60				650						740
12			500				400						900
13			0										0
14			700	70	60								830
15					45								45
16					150								150
17				5									5
18							0						0
19							0						0
20							20						20
21							450						450
22							90						90
23							10						10
24							150						150
25							40						40
26			5										5
27			0		10								10
28			100										100
29			40										40
30							10						10
31			3										3
32					10								10
33							0						0
34							10						10
36	0												0
37	0												0
38												**	-
39												**	-
40												**	-
41												**	-
42								130					130
43									225				225
44											0		0
45						20							20
46										0			0
TOTAL	0	1140	1563	75	275	20	2140	130	225	0	0	**	5568

* Potential Major Source of AMD Pollution if Erosion Continues (culm deposits covered)

** In Potato Creek Watershed - No Measurements

The following is the percent of the total average daily acid load contributed by sources within the tributary sub-basin for each tributary stream.

Miles of Polluted Streams

The miles of stream polluted by acid mine drainage in the East Branch Clarion

<u>Tributary Stream</u>	<u>Average Daily Acid Load lbs. per day</u>	<u>Percent of Total Acid Load</u>
Swamp Creek	2,703	48.5
Johnson Run	2,140	38.5
Yonkers Run	275	4.9
Gum Boot Run	225	4.0
Twomile Run	130	2.3
Borgardy Run	75	1.4
Smith Run	20	0.4
	<u>5,568</u>	<u>100.0</u>

River Watershed, including the main branch of the East Branch Clarion River below the mouth of Twomile Run and the branches of tributary streams affected by acid discharges, is estimated to be about 43.95 miles.

The following is a summary of the total miles of polluted stream in the watershed.

<u>Sub-Basin</u>	<u>Miles of Polluted Stream</u>
Main Branch of the East Branch Clarion River	15.60
Johnson Run Sub-Basin	12.05
Swamp Creek Sub-Basin	9.15
Yonkers Run Sub-Basin	1.95
Borgardy Run Sub-Basin	1.90
Gum Boot Run Sub-Basin	1.70
Twomile Run Sub-Basin	0.95
Smith Run (to confluence with Cold Spring Run)	<u>0.65</u>
TOTAL	43.95 miles

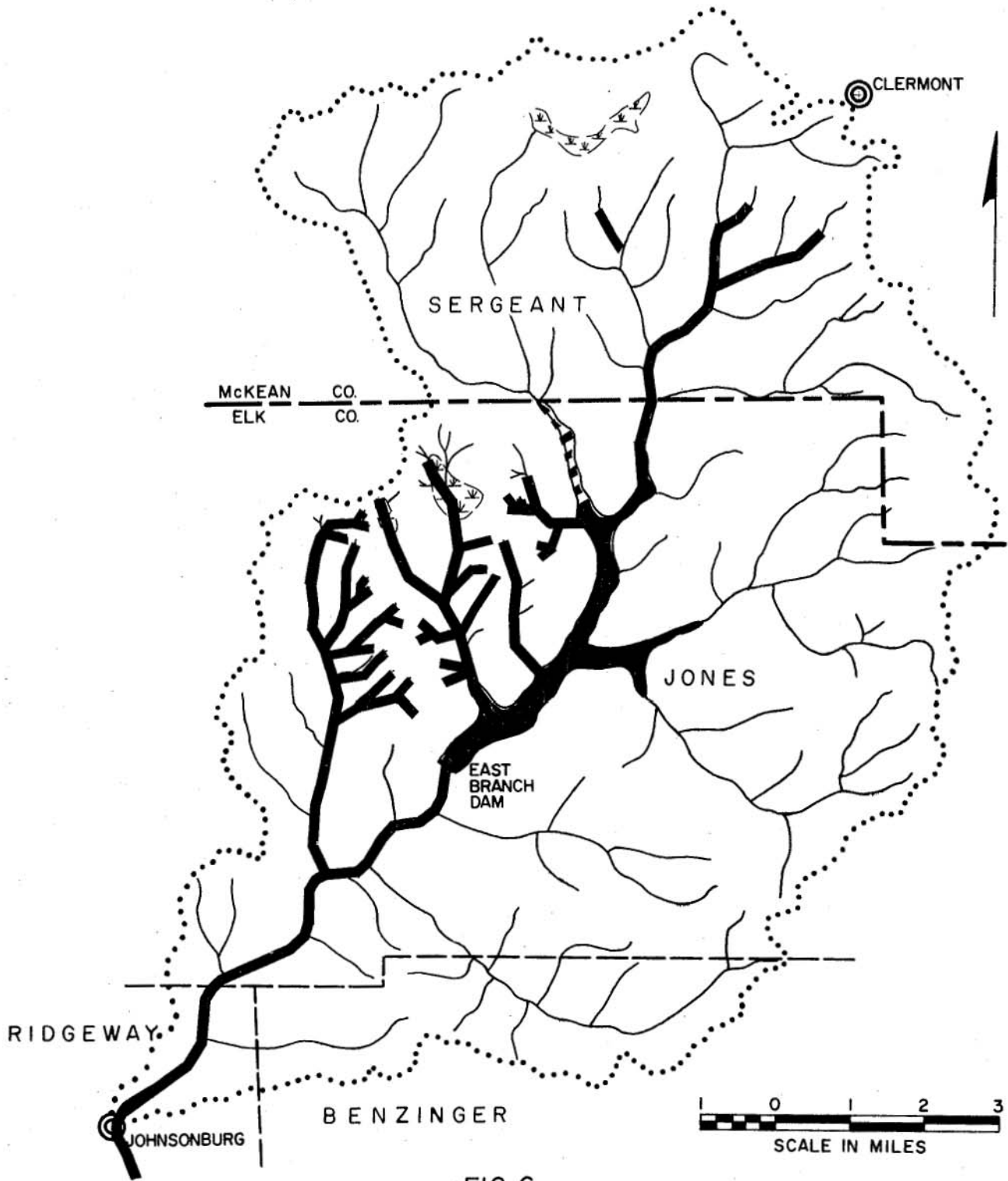


FIG. 6
 LOCATION MAP
 EAST BRANCH CLARION RIVER DRAINAGE BASIN

— STREAMS POLLUTED BY ACID MINE DRAINAGE

Strip-Mining the Main Cause of Pollution

Strip-mining, which began shortly before 1948, is responsible for over 80 percent, or about 4, 500 lbs. per day of the total average daily acid discharge.

This percentage may be conservative for the following three reasons:

1. The high estimated average acid discharge of 450 lbs. per day attributed to the Bucktail Mines, Area 21, appears to be mostly the direct result of strip-mining in the area of the deep mine and not the result of the deep mining operation which occurred a number of years before strip-mining began. The Bucktail Mines were sealed in 1947, but shortly thereafter stripping along the crop line destroyed the mine seals resulting in significant acid discharges from the mine.
2. The H. C. Quinn Mine, Area 16, which has an estimated average acid discharge of 150 lbs, per day appears to receive groundwater flow from the Area 14 strip-mine just to the north of the mine workings.
3. The early water quality test data and the fact that deep mines producing significant acid discharges were sealed, indicate deep mines were not a significant source of acid mine drainage pollution. This is in spite of the fact that strip-mining did completely strip a number of deep mines in the East Branch Clarion River Watershed, particularly at the location of the Area 14 strip-mine.

On the basis of the early water quality test data obtained mostly from the Pennsylvania Department of Health and on knowledge that the deep mines producing significant acid discharges were sealed, it is concluded the deep mine sources in the East Branch Clarion River Watershed prior to strip-mining probably produced less than 10 percent of the present estimated total average daily acid discharge of 5, 600 lbs. per day.

Water Quality of the East Branch Clarion River

For a watershed in Western Pennsylvania with a drainage area of about 109 square miles, the total estimated average daily acid discharge of 5,600 lbs. per day from the pollution sources is small, but it is highly significant because the clean streams are marginally alkaline and do not have the ability to neutralize this relatively small acid discharge. The acid discharges are also significant because an average daily acid load of about 3,300 lbs. per day enters the East Branch Reservoir which is the center of a recreational area.

The reason the streams do not have much alkalinity is because the watershed is almost entirely underlain by coal seams and there is little limestone or rocks that contain calcareous minerals which would tend to neutralize the acid discharges.

Maximum Acid Discharges

The following is the estimated maximum acid discharge at the mouth of each tributary stream polluted by acid mine drainage. This estimate is for the study period and is made on the basis of water quality tests performed over a one year period. For comparison the estimated average daily acid discharge at the mouth of each stream during the study period is also shown.

Estimated Acid Discharge at Mouth of Polluted Tributary Streams

<u>Tributary Stream</u>	<u>Average Acid Discharge</u> <u>lbs. per day</u>	<u>Maximum Acid Discharge</u> <u>lbs. per day</u>
Swamp Creek	2,625	8,800
Johnson Run	2,000	8,175
Yonkers Run	274	851
Gum Boot Run	225	649
Twomile Run	130	400
Borgardy Run	50	325
Smith Run	Less than 1	60

Analysis of the water quality test data indicates the total acid discharge in the East Branch Clarion River Watershed can more than triple when there is a large increase in surface runoff. There is some correlation between acid discharge and stream flow, but at some of the sampling stations the maximum acid discharge did not occur at the time of the maximum recorded stream flow.

In general, during the study period, the maximum stream flow and maximum acid discharges occurred in April and the minimum stream flow and acid discharges occurred in October. The period June through October, had low stream flows and low acid discharges.

Water Quality Indicators

For periods of below average stream flow, there appears to be some correlation between the parameters pH, total acidity, free acidity, sulfate and total iron as the concentrations in mg/ l increased and the pH was lower, but in many cases this was not the maximum concentration of an individual parameter.

There does not appear to be much correlation between the water quality indicators and above average stream flow, with the exception of maximum stream flow at some sources where the concentrations of the parameters were low and pH was above average. For periods of above average stream flow, the time interval between precipitation,, and possibly ground temperature, appear to be more of a controlling factor.

When two sampling stations are compared, there does not appear to be much correlation between stream flow and the acid concentrations

Precipitation Data

There appears to be two distinct precipitation patterns in the East Branch Clarion River Watershed. Data was collected from two weather stations:

1. Glen Hazel 2NE Dam, Elk County, Pa., at the East Branch Dam, and
2. Clermont, McKean County, Pa. , which is just outside the headwaters of the East Branch Clarion River and about 11 miles northeast of the Glen Hazel weather station.

The Glen Hazel weather station is considered as recording the actual precipitation occurring in, the Swamp Creek and Johnson Run Sub-Basins, and the Clermont Weather Station would be typical of precipitation occurring in the Gum Boot Run and Twomile Run Area.

The recorded precipitation for the two weather stations for the period 1951 through 1969 is shown on the following pages. Throughout most of the history of the two weather stations, the annual precipitation at Clermont has averaged several inches less. In the year 1969, during the study period, the annual precipitation at Clermont was almost 13 inches less than the precipitation recorded at Glen Hazel. The difference for the year 1969 was extreme, and should be treated with suspicion until the State Climatologist is able to check the self recording apparatus.

Histograms for the study period were constructed for the two weather stations to show the monthly precipitation in inches versus the mean precipitation in inches for an 18 year period, and also the months with above average precipitation. An examination of the precipitation data for the study period shows while precipitation for the individual months varied considerably, the long term precipitation month by month does not vary greatly. As an example, for the 18 year record at Glen Hazel, the highest average precipitation was 4.62 inches for the month of July and lowest average precipitation was 2.72 inches in the month of February, a difference of 1.90 inches. This may mean the total yearly acid discharge could vary considerably from year to year, but over a longer period, say ten years, an average yearly discharge could be computed for the watershed that would be more meaningful.

It should be noted 1962 through 1964 were drought years and, at Glen Hazel, maximum inches of monthly rainfall occurred in the early 1950's.

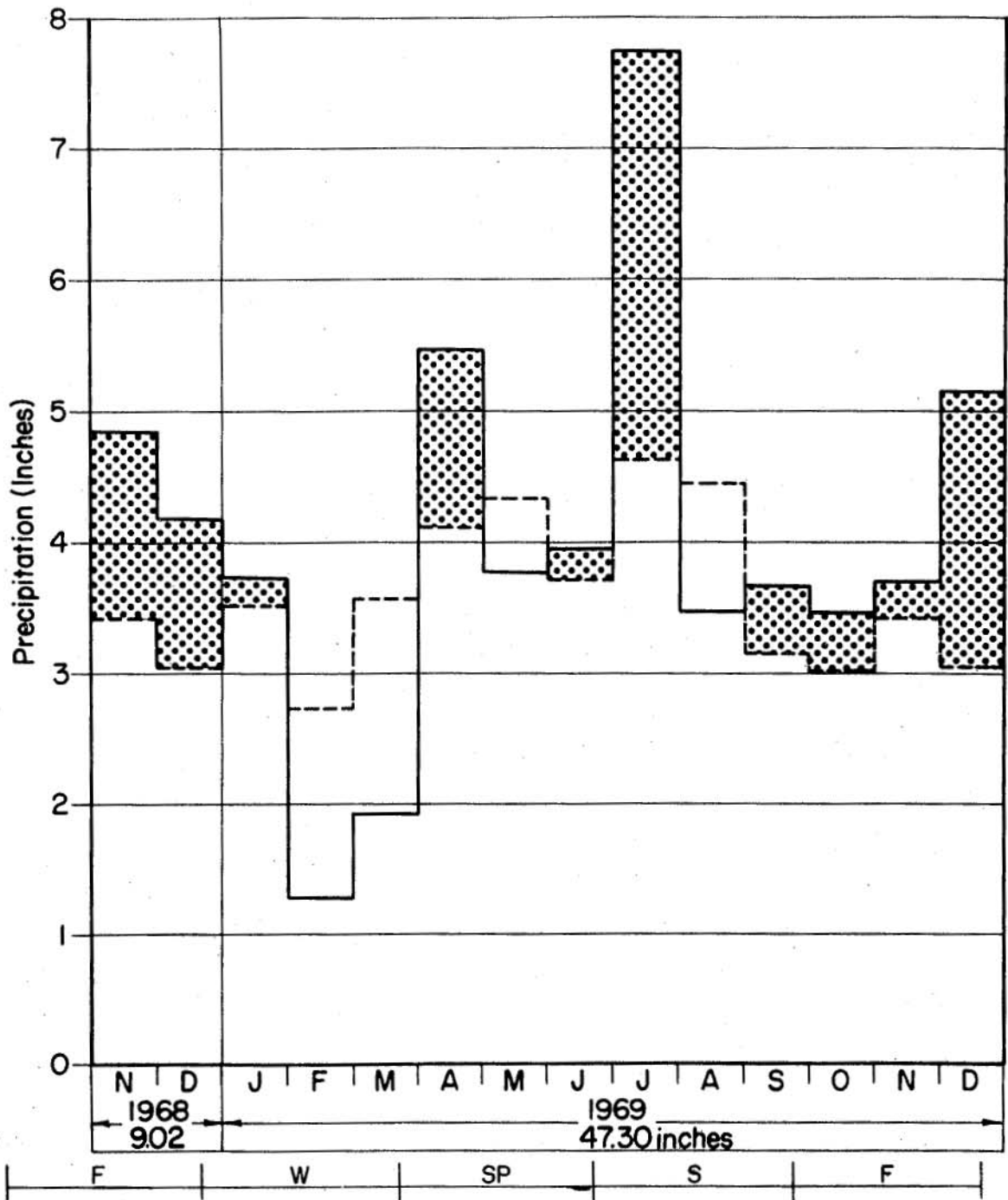
There does not appear to be any correlation between precipitation and acid discharge, except possibly seasonally. This is to be expected because the East Branch Clarion River Watershed, for the most part, has a heavy hardwood forest canopy.

During the growing season, the forest canopy intercepts 15 to 20 percent of the rainfall before it reaches the forest floor, but during the winter, or dormant season, only about 7 percent of the precipitation is intercepted. In a heavily forested area, about 80 percent of the runoff occurs during the dormant season and about three-fourths of the evapotranspiration occurs during the six month growing season.


In a forested area, such as the East Branch Clarion River Watershed, the soils range from 2 to 5 feet in depth. Starting from a dry state these soils could retain 4 to 10 inches of water. Their storage potential, particularly during the frequent dry periods in summer, is such that very little summer precipitation reaches stream flow or the groundwater table,

The greater evapotranspiration from forest -areas during the growing season and higher rates of infiltration permit greater storage of summer rainfall and consequently less runoff. The greater high flows from forested watersheds are largely a winter phenomenon: and in part can be attributed to the melt of accumulated snow under the influence of winter and early spring thaws. This holds true for the study area as the high flows and high acid discharges were during the winter and early spring.

FIG. 7

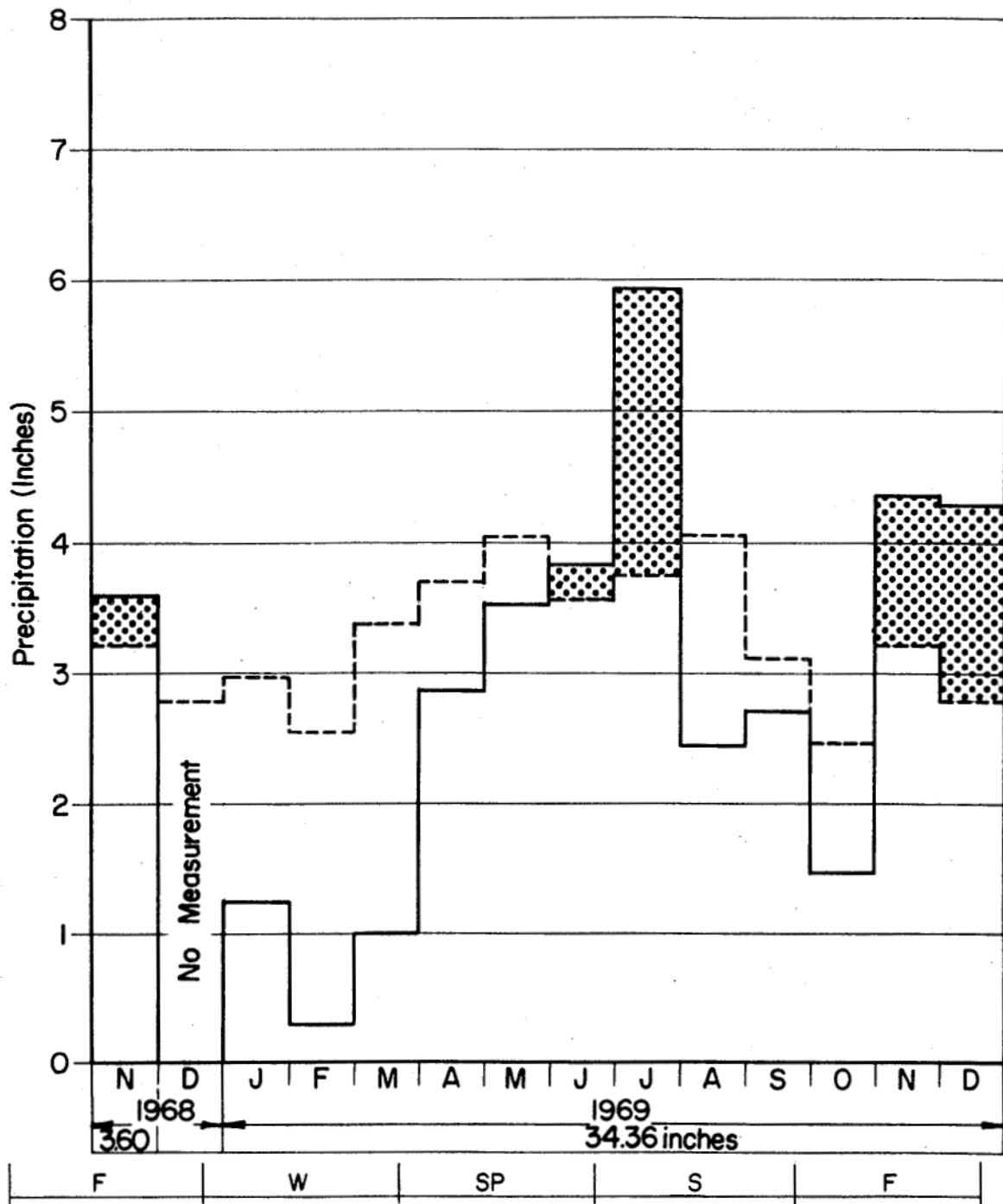


PRECIPITATION DATA FOR STUDY PERIOD


- Recorded Precipitation
- - - Mean Precipitation 1952-1969 (18 years)
-  Above Mean Precipitation

WEATHER STATION: Glen Hazel 2 NE Dam
Elk County, Pa.

FIG. 8

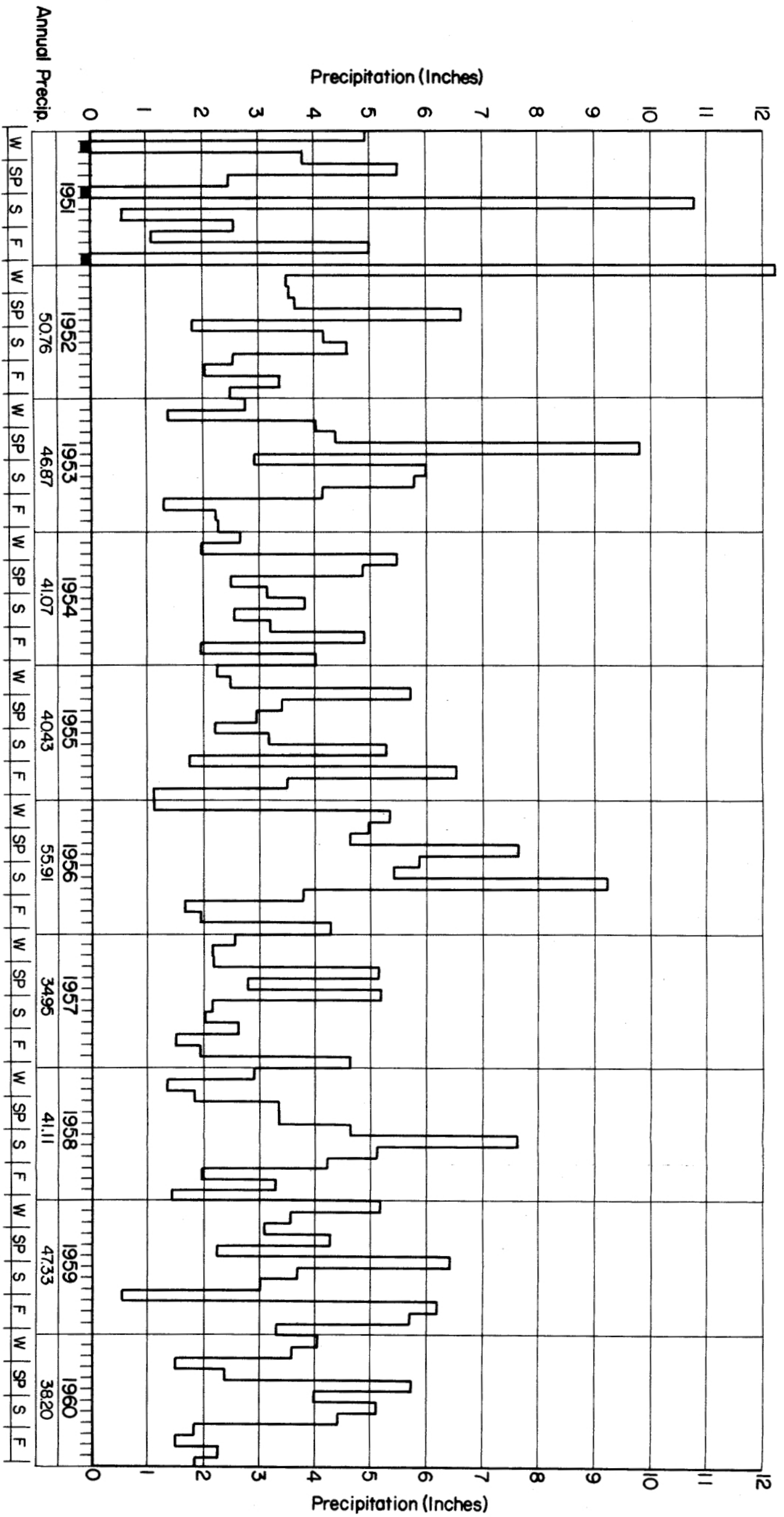


PRECIPITATION DATA FOR STUDY PERIOD

- Recorded Precipitation
- - - Mean Precipitation 1952-1969 (18 years)
-  Above Mean Precipitation

WEATHER STATION: Clermont
McKean Co., Pa.

FIG. 9

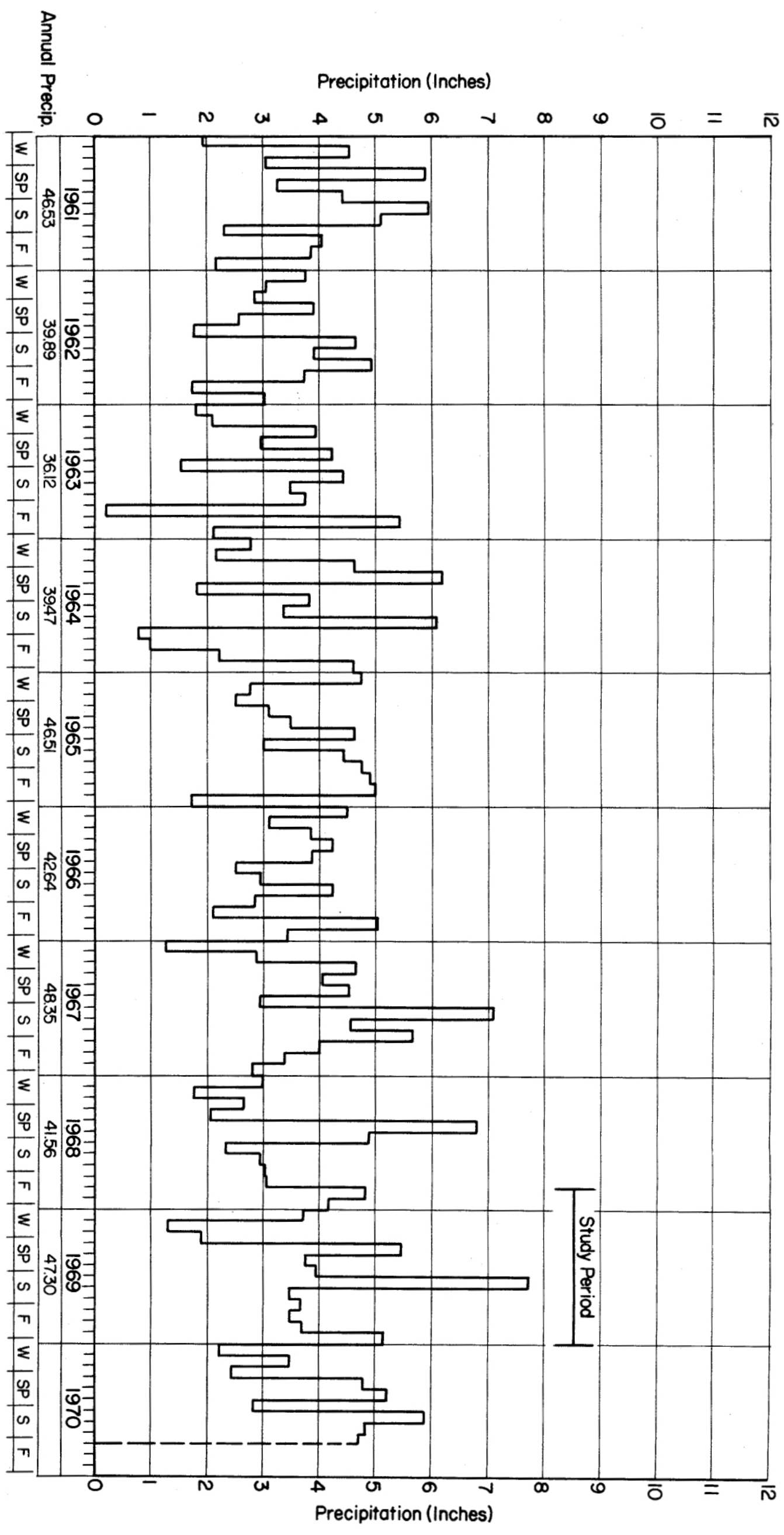


DATA FROM U.S. DEPT. OF COMMERCE
 WEATHER STATION: Glen Hazel 2 NE Dam Elk County, Pa.
 Latitude 41°34' Longitude 78°36'
 Elevation 1725'
 OBSERVER: Corps of Engineers

No Measurement
 1951

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 OPERATION SCARLIFT
 PROJECT SL-108
 EAST BRANCH CLARION RIVER
 Elk & McKean Counties
 PRECIPITATION DATA 1951-1960 GLEN HAZEL
 MICHAEL BAKER, JR., INC.
 ROCHESTER, PENNSYLVANIA

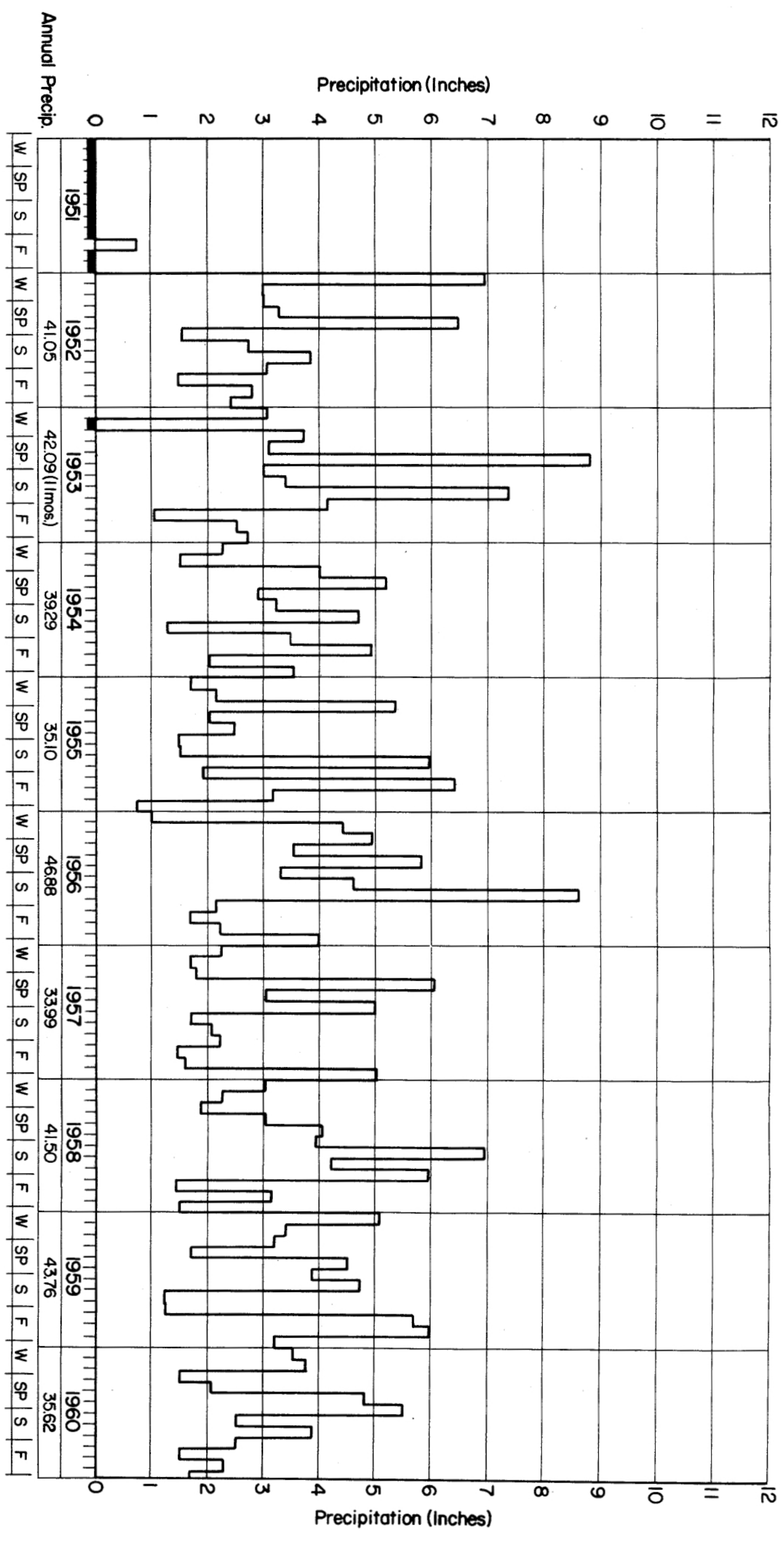
FIG. 10



DATA FROM U.S. DEPT. OF COMMERCE
 WEATHER STATION: Glen Hazel 2NE Dam Elk County, Pa.
 Latitude 41° 34' Longitude 78° 36'
 Elevation 1725'
 OBSERVER: Corps of Engineers

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 DEPARTMENT OF MINES & MINERAL INDUSTRIES
 OPERATION SCARLIFT
 PROJECT SL-108
 EAST BRANCH CLARION RIVER
 Elk & Mckean Counties
 PRECIPITATION DATA 1961-1970 GLEN HAZEL
 MICHAEL BAKER, JR., INC.
 ROCHESTER, PENNSYLVANIA

FIG. 11

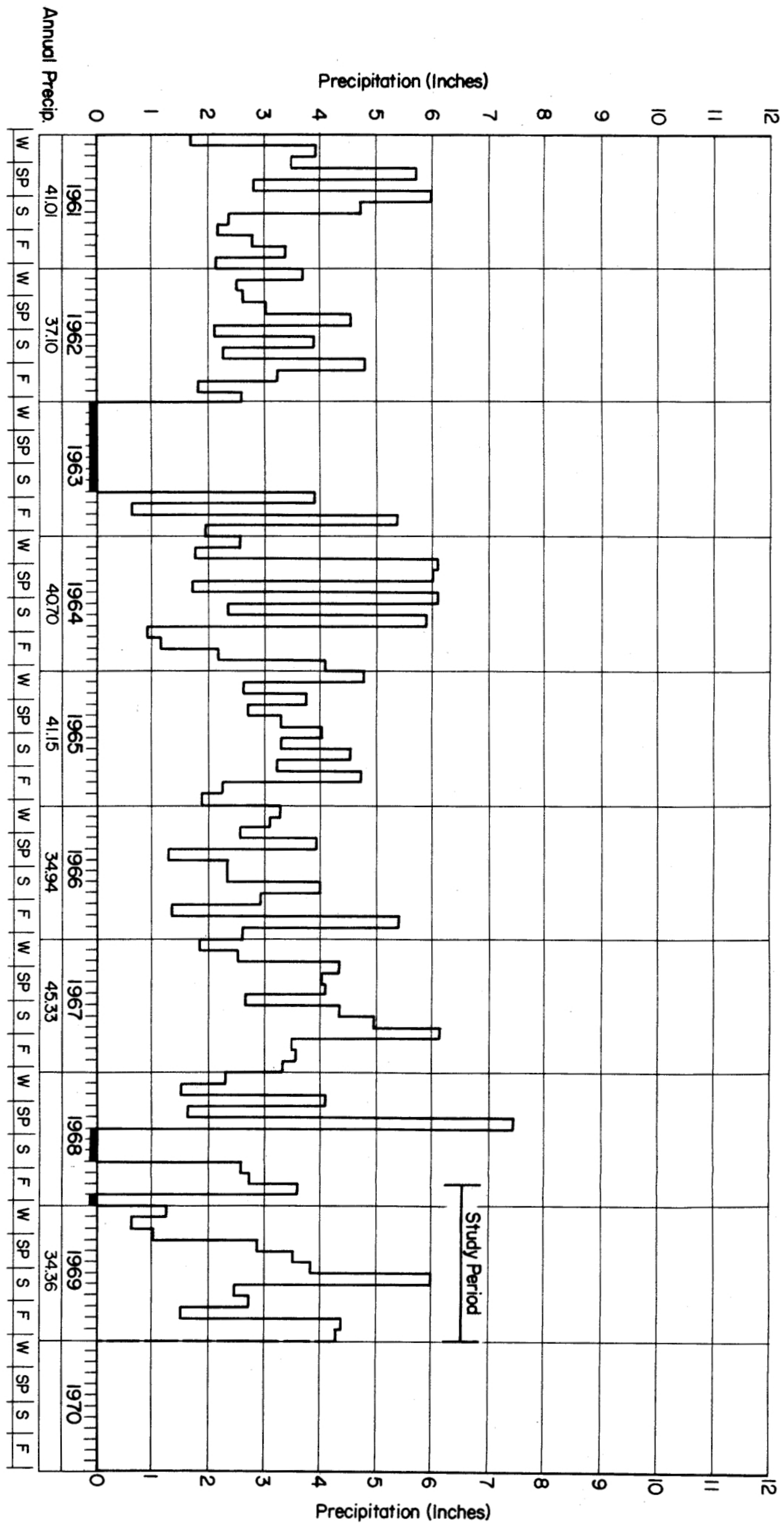


DATA FROM U.S. DEPT. OF COMMERCE
 WEATHER STATION: Clermont, McKean County, Pa.
 Latitude 41° 41' Longitude 78° 30'
 Elevation 2104'
 OBSERVER: Mrs. Tillie M. Simonds

No Measurement
 1953

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 DEPARTMENT OF MINES & MINERAL INDUSTRIES
 OPERATION SCARLIFT
 PROJECT SL-108
 EAST BRANCH CLARION RIVER
 Elk & McKean Counties
 PRECIPITATION DATA 1951-1960 CLERMONT
 MICHAEL BAKER, JR., INC.
 ROCHESTER, PENNSYLVANIA

FIG. 12



DATA FROM U.S. DEPT. OF COMMERCE
 WEATHER STATION : Clermont, McKean County, Pa.
 Latitude 41° 41' Longitude 78° 30'
 Elevation 2104'
 OBSERVER: Mrs. Tillie M. Simonds



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 PRECIPITATION DATA 1961-1970 CLERMONT