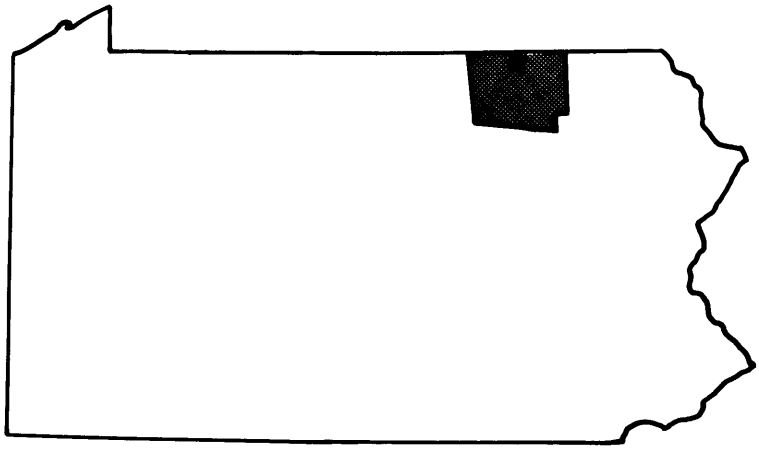
FLOOD INSURANCE STUDY

BOROUGH OF SAYRE, PENNSYLVANIA
BRADFORD COUNTY



OCTOBER, 1976

U.S. DEPARTMENT of HOUSING & URBAN DEVELOPMENT
FEDERAL INSURANCE ADMINISTRATION

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FLOOD INSURANCE STUDY
BOROUGH OF SAYRE, PENNSYLVANIA

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Flood Insurance Study is to investigate the existence and severity of flood hazards in the Borough of Sayre, Bradford County, Pennsylvania, and to aid in the administration of the Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial use of this information will be to convert Sayre to the regular program of flood insurance by the Federal Insurance Administration. Further use of the information will be made by local and regional planners in their efforts to promote sound land use and flood plain development.

1.2 Coordination

The Northern Tier Regional Planning and Development Commission was contacted for information concerning flooding problems within the Borough of Sayre. Flood discharge information was coordinated with the U. S. Army Corps of Engineers and the United States Geological Survey.

A final coordination meeting for the Borough of Sayre was held on September 9, 1975 between representatives of the Federal Insurance Administration, the Project Contractor and community officials. The draft study was acceptable by everyone present at the meeting.

1.3 Authorization and Financing

This Flood Insurance Study was conducted by the Susquehanna River Basin Commission at the request of the Federal Insurance Administration, U. S. Department of Housing and Urban Development. The source of authority for the study is the National Flood Insurance Act of 1968, as amended. Authority and financing are contained in Contract No. H-3496 between the contractor and the Federal Insurance Administration.

1.4 Acknowledgements

Work maps for this study were compiled by L. Robert Kimball, Consulting Engineers. Profiles and floodways were computed and flood boundaries were delineated by Century Engineering for the Susquehanna River Basin Commission.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Borough of Sayre. The area of study is shown on the Vicinity Map (Figure 1).

Floods caused by overflow of the Susquehanna River and Cayuta Creek were studied by detailed methods within the community.

2.2 Community Description

The Borough of Sayre is located in the north central portion of Bradford County in northeastern Pennsylvania. Its northern border forms part of the Pennsylvania-New York State line. Located within Athens Township, Sayre is bordered in part on the west by the Borough of South Waverly, on the north by the Village of Waverly, New York, and on the south by the Borough of Athens. The 1970 population of 7,473 represents a 5.6 percent decrease from the 1960 figure (7,917).

The Susquehanna River flows in a north to south direction while forming the eastern border of the community. Cayuta Creek flows in a southeasterly direction through the Borough and joins with the Susquehanna River at a point 1,000 feet upstream from the East Lockhart Street Bridge.

Flood plains in the eastern half of the Borough, have, historically, been subject to flood damage. This area contains commercial, industrial and some residential development.

Regional temperatures generally range between 37 and 59 degrees Fahrenheit with a 49 degree annual average. The average annual precipitation is 34 inches with seasonal snowfall averaging 42 inches. Precipitation is reasonably well distributed throughout the year although up to several inches more is received during the warmer months. During the June to October period, tropical storms and hurricanes are a source of appreciable rainfall; amounts up to 10 inches may occur in 24 to 48 hours. Fortunately, such storms affect the area on the average of only once every 2 to 3 years.

2.3 Principal Flood Problems

Based on historical information, the Susquehanna River and Cayuta Creek are the principal sources of flooding problems in the Borough

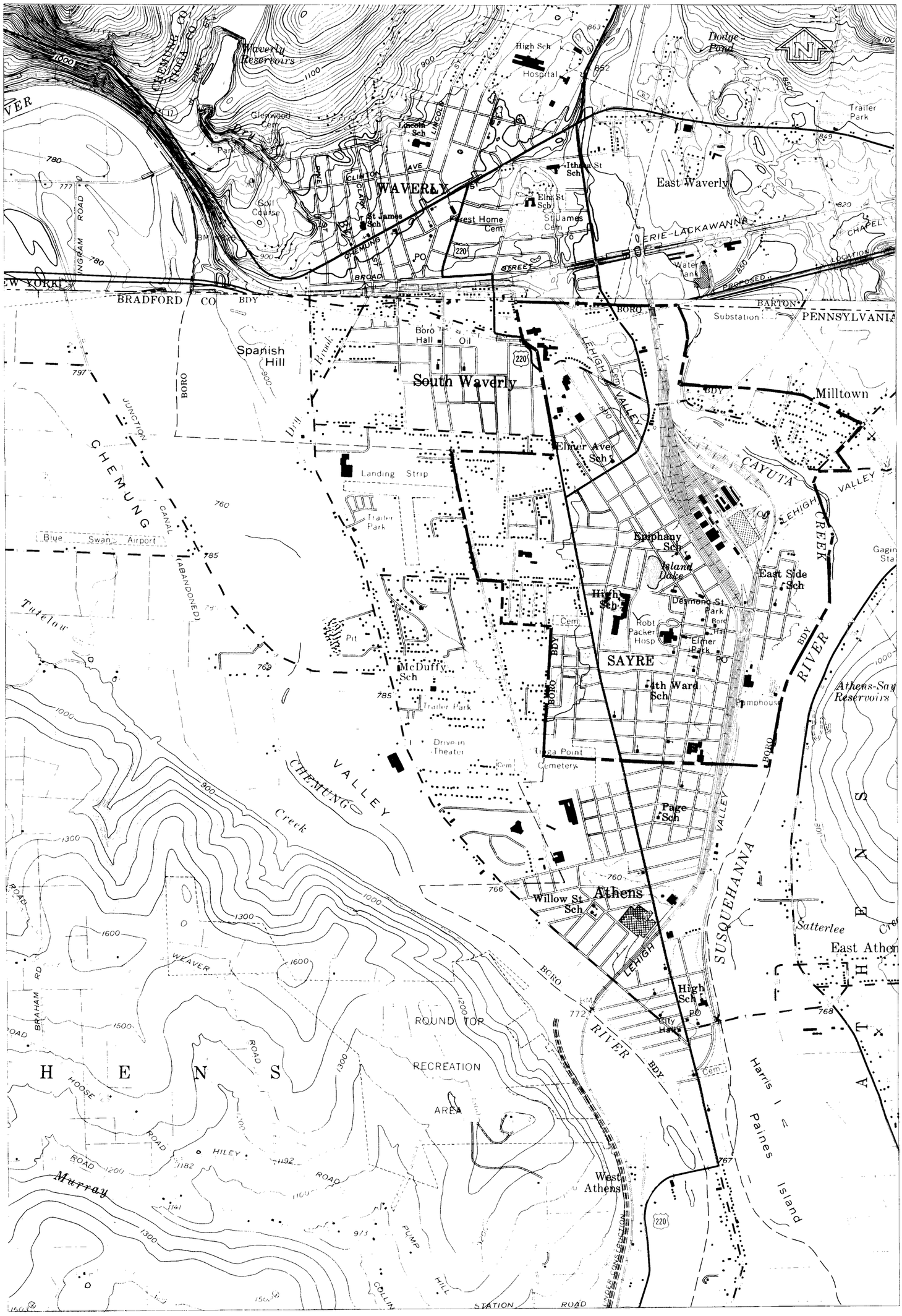


FIGURE 1

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

BOROUGH OF SAYRE, PA
(BRADFORD CO.)

APPROXIMATE SCALE
0 2000 4000 6000 8000 FEET

VICINITY MAP

of Sayre. Intermittent records of flood stages at scattered localities on the Susquehanna above Sayre date back to 1810. Numerous earlier floods are mentioned in historical records as far back as 1740. The most severe flooding ever recorded occurred along the Susquehanna on June 23 and 24, 1972 as a result of Hurricane Agnes. At the Susquehanna River gaging station located 1,000 feet upstream from the confluence with Cayuta Creek, a peak flood crest of 765.2 feet was recorded.

2.4 Flood Protection Measures

There is an existing local flood protection project, consisting of earth dikes along the Susquehanna River and a portion of Cayuta Creek, which reduces the potential flood hazard to the Borough of Sayre. These dikes are overtopped by the 500-year flood. Two existing upstream dams contribute to the reduction of the flood hazard from the Susquehanna . These are: Whitney Point Lake on the Otselic River and East Sidney Lake on Ouleout Creek.

3.0 ENGINEERING METHODS

For flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Floods having recurrence intervals of 10-, 50-, 100- and 500-years have been selected as having special significance for flood plain management and for flood insurance premium rates. The analyses reported here reflect current conditions in the watersheds of the streams.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each stream studied in detail in the Borough of Sayre.

The discharges for the Susquehanna River were obtained from a log-log plot of discharges against drainage area for different subbasins of the Susquehanna. Discharges for this analysis were obtained from existing flood-frequency curves for gaging stations on the Susquehanna as published by the Corps of Engineers. The discharges used for the Susquehanna River at Sayre were essentially the same as those obtained from the flood-frequency curve for the gaging station near Waverly, New York. This gage, located 2,000 feet upstream from the East Lockhart Street Bridge at Sayre, has been in operation since 1936.

Discharges for Cayuta Creek were determined by a regional flood-frequency method developed by the Corps of Engineers (Reference 8).

Frequency-discharge, drainage area curves for streams studied in detail are shown in Figure 2. Due to insignificant variations in drainage areas between the study limits, only point values have been depicted for the Susquehanna River and Cayuta Creek.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals for each stream studied in detail.

Water-surface profiles for floods of the selected recurrence intervals were developed through use of the Corps of Engineers HEC-2 step-backwater computer program (Reference 2). Flood Profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot (Exhibit 1). All elevations were based on mean sea level datum.

Cross sections used in the hydraulic computations were located at regular intervals along each stream studied in detail and at significant changes in ground relief and land use or land cover. Ground elevations for cross sections on both the Susquehanna River and Cayuta Creek were obtained from aerial photographs. Below-water cross section data for the Susquehanna were obtained from existing channel profiles provided by the Corps of Engineers; Cayuta Creek channel elevations were field surveyed. The locations of selected cross sections are shown on the Flood Boundary and Floodway Map (Exhibit 2).

Channel lengths were measured along the centerline of the channel between cross sections. Overbank lengths were measured along the approximate centerline of the effective overbank area.

Roughness coefficients (Manning's "n") were estimated from aerial and ground photographs, topographic maps and field inspection. The hydraulic model was then tested and the "n" values adjusted within an acceptable range to best fit known highwater marks and/or elevations at gaging stations along the Susquehanna River. For Cayuta Creek, it was not possible to verify the roughness coefficients as no known highwater marks were available. For the Susquehanna River within the Borough of Sayre, the roughness coefficient used for the main channel was 0.027 and for the overbank areas was 0.085.

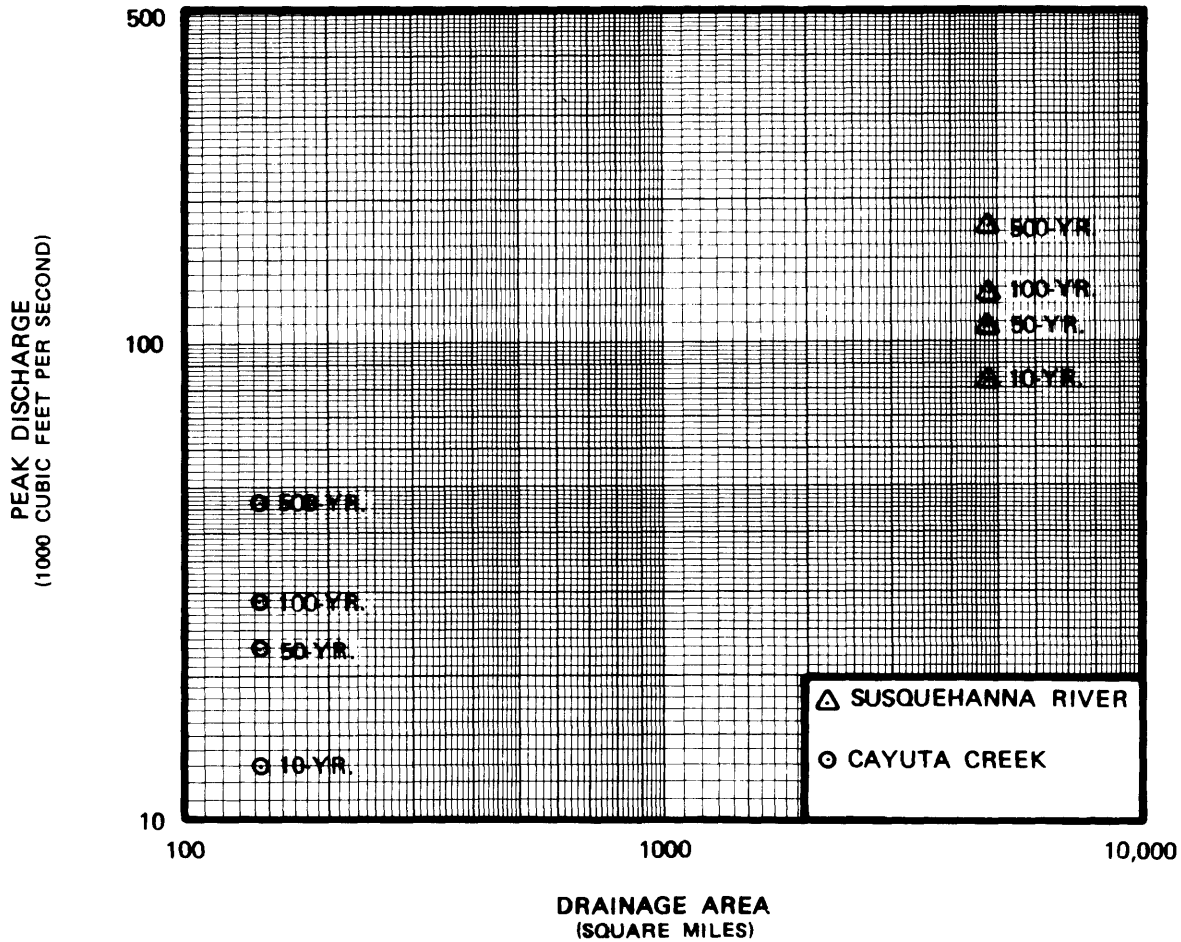


FIGURE 2

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

BOROUGH OF SAYRE, PA
(BRADFORD CO.)

FREQUENCY-DISCHARGE, DRAINAGE AREA CURVES

SUSQUEHANNA RIVER AND CAYUTA CREEK

Along Cayuta Creek, the channel "n" value ranged between 0.042 and 0.048 and the overbank "n" value ranged between 0.035 and 0.085.

Highwater marks, used to test the hydraulic model for the Susquehanna River, were obtained by the United States Geological Survey for the June 1972 flood. All gaging station elevations used were based on established rating curves.

Starting elevations for backwater computations on the Susquehanna River were determined by the slope area method at the first river cross section located 5.3 miles downstream from the Borough of Sayre. For Cayuta Creek, starting elevations were computed by the slope-area method at the confluence with the Susquehanna River. Elevation Reference Marks are shown and described on the Flood Boundary and Floodway Map (Exhibit 1) and the Flood Insurance Rate Map.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage state and local governments to adopt sound flood plain management programs. Each Flood Insurance Study, therefore, includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Insurance Administration as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100-year and the 500-year flood have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2,400 with a contour interval of 5 feet (Reference 7). In cases where the 100-year and the 500-year flood boundaries are close together, only the 100-year boundary has been shown.

Small areas within the flood boundaries may lie above the flood elevations, and therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood carrying capacity and increases flood heights, thus increasing flood

hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a proposed floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment in order that the 100-year flood be carried without substantial increases in flood heights. As minimum standards, the Federal Insurance Administration limits such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced.

The floodway proposed for this study was computed on the basis of equal conveyance reduction from each side of the flood plain. In areas where encroachments, extending beyond the tops of stream banks, did not produce a rise in the water-surface of more than 1.0 foot, the channel banks were designated as the floodway boundaries. The results of these computations are tabulated at selected cross sections for each stream studied in detail (Table 1). As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were determined at cross sections; between cross sections the boundaries were interpolated.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 3.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the Federal Insurance Administration has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the Borough of Sayre.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	WITH FLOODWAY (M.S.L.)	WITHOUT FLOODWAY (M.S.L.)	DIFFERENCE (FT.)
Susquehanna River							
A	0[1]	1,019[3]	15,276	8.3	764.0	763.1	0.9
B	1,570[1]	681[3]	14,155	9.1	764.7	764.1	0.6
C	3,340[1]	972[3]	18,678	7.1	766.0	765.3	0.7
D	3,455[1]	972[3]	18,715	7.1	766.1	765.3	0.8
E	3,880[1]	1,218[3]	23,497	5.6	766.8	765.8	1.0
Cayuta Creek							
A	1,830[2]	1,033[3]	5,590	5.2	760.8	760.8	0.0
B	2,245[2]	615[3]	4,225	6.9	762.1	762.0	0.1
C	2,745[2]	256[3]	1,971	14.7	763.9	763.2	0.7
D	3,015[2]	266[3]	2,804	10.3	767.5	768.8	-1.3
E	3,995[2]	866	6,544	4.4	771.4	771.6	-0.2
F	5,055[2]	540	2,957	9.8	773.1	772.8	0.3
G	6,125[2]	645	3,695	7.8	779.8	779.0	0.8
H	6,615[2]	520	4,384	6.6	781.1	780.7	0.4
I	7,085[2]	495	2,789	10.4	786.3	786.2	0.1
J	7,180[2]	475	3,360	8.6	787.0	787.2	-0.2
K	7,290[2]	530	3,902	7.4	787.8	787.9	-0.1
L	8,130[2]	545	4,015	7.2	790.8	790.6	0.2

[1]FEET ABOVE CORPORATE LIMITS [2]FEET ABOVE MOUTH
[3]PORTION OF FLOODWAY LOCATED OUTSIDE CORPORATE LIMITS

TABLE 1

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

BOROUGH OF SAYRE, PA
(BRADFORD CO.)

FLOODWAY DATA

SUSQUEHANNA RIVER AND CAYUTA CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	WITH FLOODWAY (M.S.L.)	WITHOUT FLOODWAY (M.S.L.)	DIFFERENCE (FT.)
Cayuta Creek (continued)							
M	8,830	1,110[2]	6,124	4.7	795.0	795.0	0.0
N	9,368	1,255[2]	5,601	5.2	796.1	796.1	0.0
O	9,935	571	2,404	12.1	797.3	797.9	-0.6

[1]FEET ABOVE MOUTH [2]PORTION OF FLOODWAY LOCATED OUTSIDE CORPORATE LIMITS

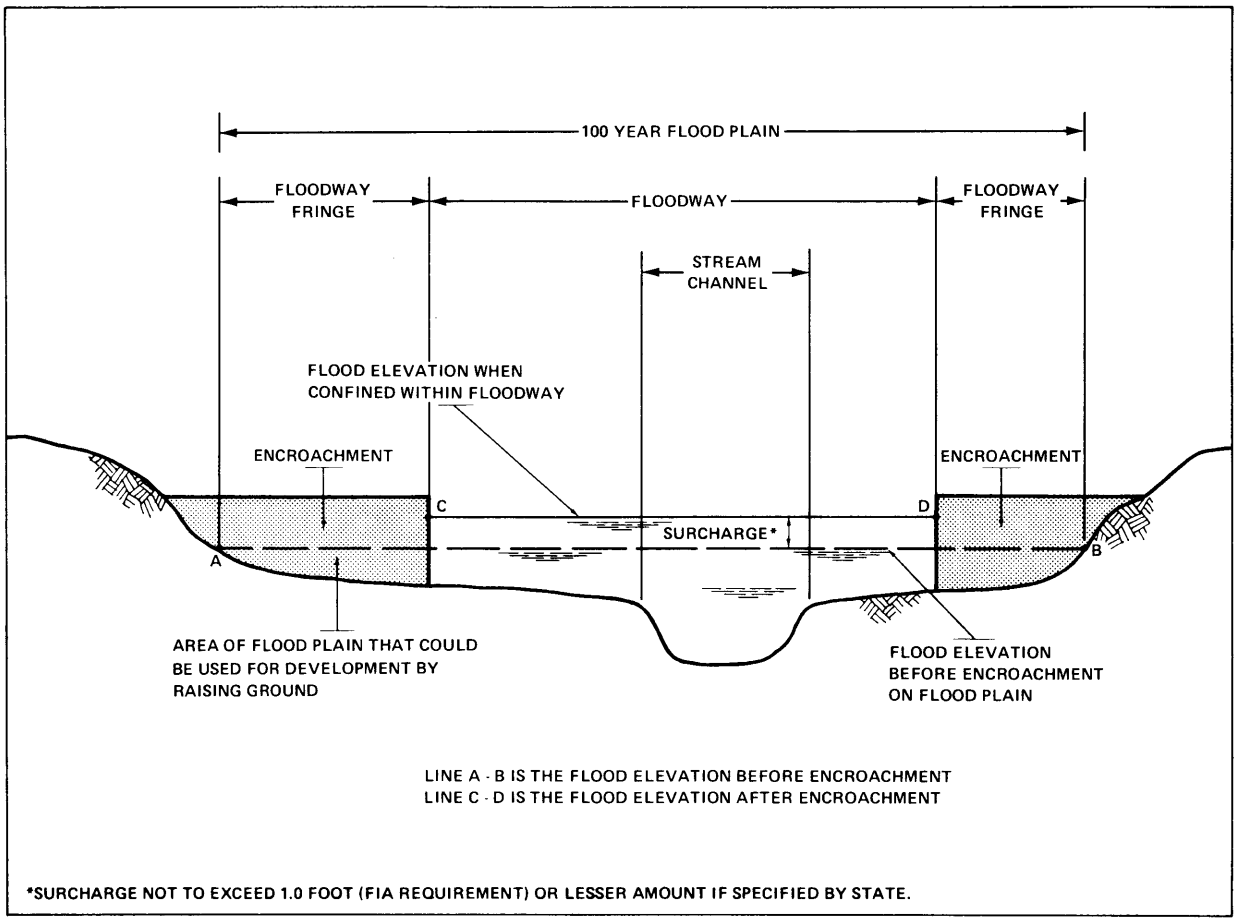
TABLE 1

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

BOROUGH OF SAYRE, PA
(BRADFORD CO.)

FLOODWAY DATA

CAYUTA CREEK



FLOODWAY SCHEMATIC Figure 3

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-year Floods	Variation
2 to 7 feet	1.0 foot

Three reaches meeting the above criterion were required for the flooding sources of Sayre. These included one on the Susquehanna River

and two on Cayuta Creek. The locations of the reaches are shown on the Flood Profiles (Exhibit 1).

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the Federal Insurance Administration device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective Flood Hazard Factors, the entire incorporated area of Sayre was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special flood hazard areas inundated by the 100-year flood determined by approximate methods; no base flood elevations or Flood Hazard Factors determined.
Zones A8, A9, A10:	Special flood hazard areas inundated by the 100-year flood, with base flood elevations determined and zone designations assigned according to the Flood Hazard Factor.
Zone B:	Area between Zones A8, A9, A10 and the limits of the 500-year flood.
Zone C:	Area not subject to flooding by the 500-year flood.

Table 2, "Flood Insurance Zone Data," summarizes the flood elevation differences, Flood Hazard Factors, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the Borough of Sayre is, for insurance purposes, the principal result of the Flood Insurance Study.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE BETWEEN BASE FLOOD AND:[2]			FHF	ZONE	BASE FLOOD ELEVATION[3]
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Susquehanna River							
Reach 1	01	-4.5	-2.0	4.4	045	A9	Varies
Cayuta Creek							
Reach 1	01	-5.0	-2.4	5.4	050	A10	Varies
Reach 2	01	-3.8	-1.1	2.5	040	A8	Varies

[1]FLOOD INSURANCE RATE MAP PANEL
[2]WEIGHTED AVERAGE
[3]ROUNDED TO NEAREST FOOT

TABLE 2

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

BOROUGH OF SAYRE, PA
(BRADFORD CO.)

FLOOD INSURANCE ZONE DATA

SUSQUEHANNA RIVER AND CAYUTA CREEK

This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the Federal Insurance Administration.

6.0 OTHER STUDIES

A Report on Inspection of Embankments Along the Susquehanna and Chemung Rivers prepared for the Borough of Athens, immediately downstream of the Borough of Sayre, by the Northern Tier Regional Planning and Development Commission indicates the relatively poor condition of the levees along the Susquehanna River for that Borough. This report could also be applied to the Borough of Sayre. Various other studies have been conducted concerning the flooding problems in the Sayre area but have not been presented in detailed report format and are not comparable to this study.

A Flood Insurance Study for the neighboring Borough of Athens was prepared at the same time as this report (Reference 9). There are no disagreements between the two studies.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic and other pertinent data used in this study will be on file for five years at the office of the Susquehanna River Basin Commission, 5012 Lenker Street, Mechanicsburg, Pennsylvania 17055.

8.0 BIBLIOGRAPHY AND REFERENCES

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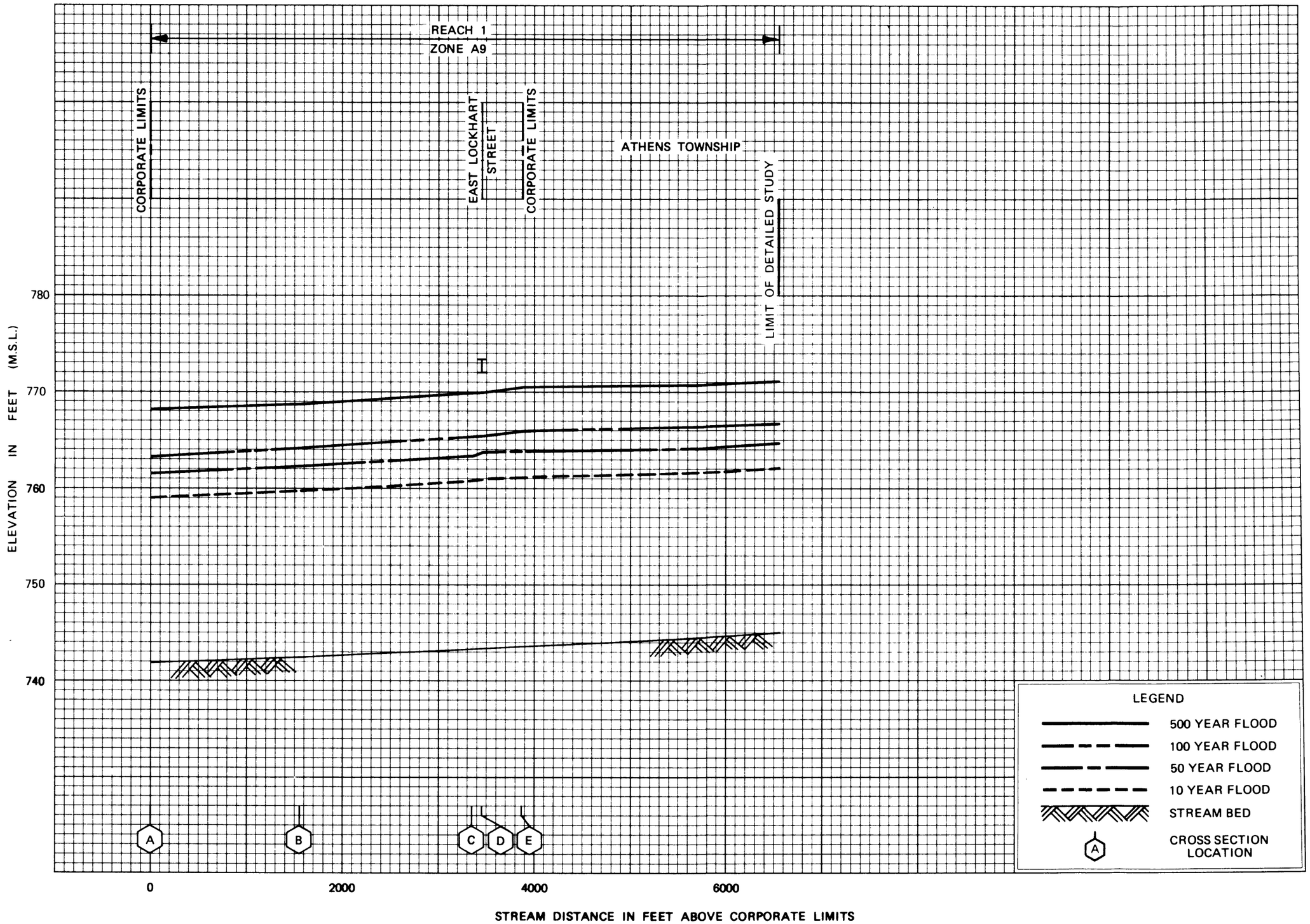


FLOOD PROFILES

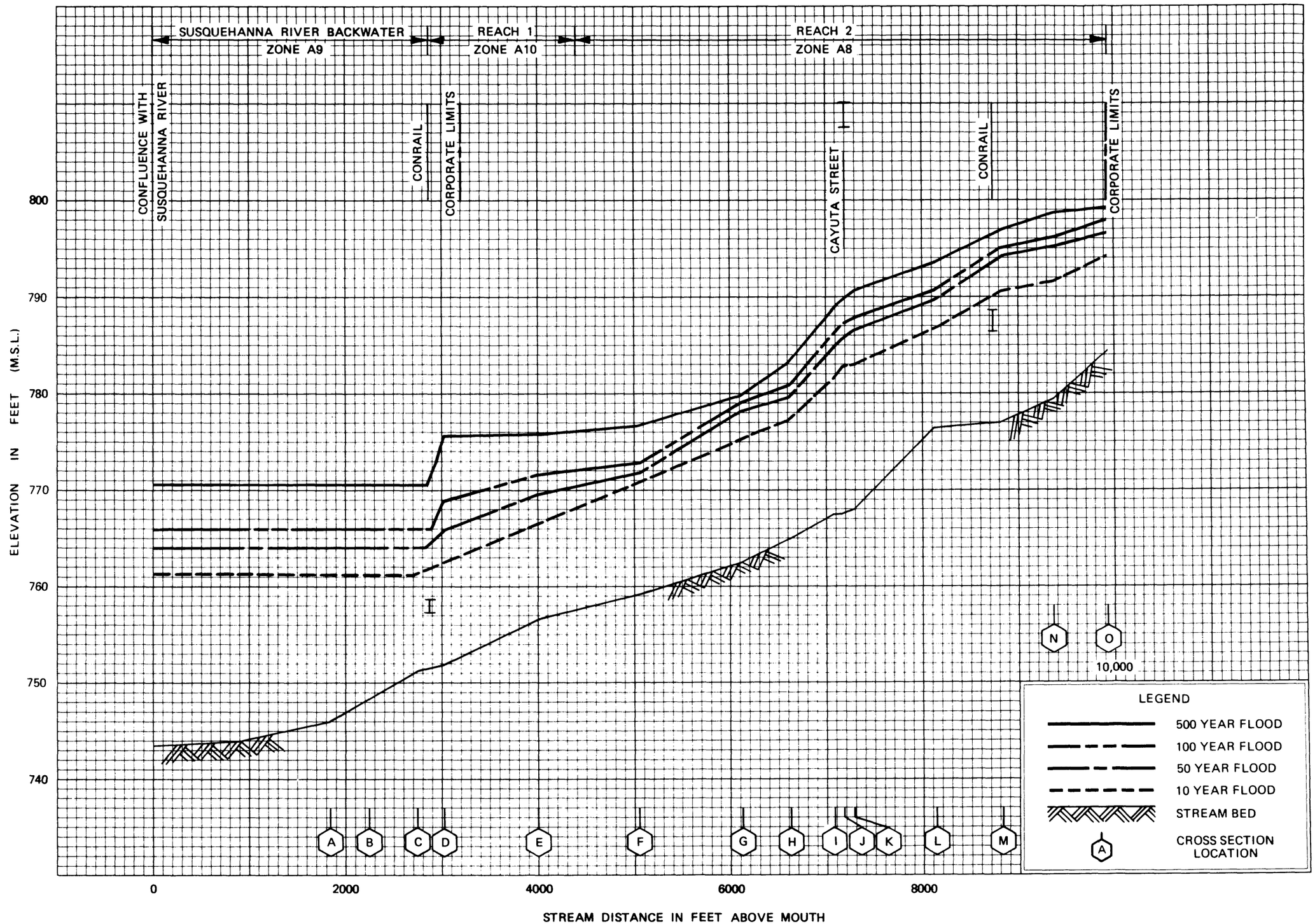
SUSQUEHANNA RIVER

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

BOROUGH OF SAYRE, PA
(BRADFORD CO.)

01P

EXHIBIT 1



FLOOD PROFILES

CAYUTA CREEK

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

BOROUGH OF SAYRE, PA
(BRADFORD CO.)

02P

EXHIBIT 1