FLOODS ON FRENCH BROAD RIVER & SPRING CREEK

Vicinity of HOT SPRINGS North Carolina

TENNESSEE VALLEY AUTHORITY

DIVISION OF WATER CONTROL PLANNING

FLOODS ON FRENCH BROAD RIVER & SPRING CREEK — VICINITY OF HOT SPRINGS, N. C.

TENNESSEE VALLEY AUTHORITY
KNOXVILLE, TENNESSEE

August 23, 1960

Colonel Harry E. Brown, Director
State of North Carolina
Department of Water Resources
Post Office Box 9392
Raleigh, North Carolina

Dear Colonel Brown:

In response to the request of the Town of Hot Springs and the North Carolina Department of Water Resources, TVA has prepared the report, Floods on French Broad River and Spring Creek, Vicinity of Hot Springs, North Carolina. The purpose of this report is to provide basic information on floods that have occurred or may occur which would be helpful in the state and local program of city planning and development at Hot Springs. We are furnishing you copies of the report for distribution to the appropriate state and city agencies and individuals.

Also, copies of the report are being furnished interested Federal agencies for their information and use.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

J. Porter Taylor, Director
Division of Navigation and
Local Flood Relations

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

FLOODS ON FRENCH BROAD RIVER AND SPRING CREEK IN VICINITY OF HOT SPRINGS, NORTH CAROLINA

REPORT NO. 0-5971

KNOXVILLE, TENNESSEE

JULY 1960

CONTENTS

CONTENTS (Continued)

TABLES

PLATES

FIGURES

COVER PHOTO

Aerial photograph shows the French Broad River flowing from southeast to northwest through Hot Springs, North Carolina, and Spring Creek entering from the southwest. The alternate blue and white dashed line shows the approximate overflow limits of the July 1916 flood.

FOREWORD

Tennessee Valley Authority
Division of Water Control Planning

FOREWORD

This report relates to the flood situation along the French Broad River and Spring Creek in the vicinity of Hot Springs, North Carolina. It has been prepared at the request of the Town of Hot Springs through the North Carolina Department of Water Resources to aid (1) in the solution of local flood problems and (2) in the best utilization of lands subject to overflow. The report is based on work the TVA has been carrying on since its beginning in connection with its water resource operations throughout the Tennessee Valley. TVA has assembled information on rainfall, runoff, historical and current flood heights, and other technical data bearing on the occurrence and magnitude of floods in localities throughout the region which provide the basis for preparation of the report.

The report does not include plans for the solution of flood problems. Rather, it is intended to provide a basis for further study and planning on the part of the town of Hot Springs in arriving at solutions to minimize vulnerability to flood damages. This might involve (1) construction of flood protection works, (2) local planning programs to guide developments by controlling the type of use made of the flood plain through zoning and subdivision regulations, or (3) a combination of the two approaches.

The report covers three significant phases of the Hot Springs flood problem. The first brings together a record of the largest known floods of the past on the French Broad River and Spring Creek. The second treats of the Regional Floods. These are derived from consideration of the largest floods known to have occurred on streams of similar physical characteristics in the same general geographical region as that of the French Broad River and Spring Creek and generally within 100 miles of Hot Springs. The third develops the Maximum Probable Floods for the French Broad River and Spring Creek. Floods of these magnitudes on most streams are considerably larger than any that have occurred in the past. They are the floods of infrequent occurrence that are considered in planning protective works, the failure of which might be disastrous.

Such floods are used by TVA in the design of the physical features of reservoirs, dams, powerhouses, and local flood protection works.

The report contains maps, profiles, and valley cross sections which indicate the extent of flooding that has been experienced and that might occur in the future in Hot Springs.

In problems concerned with the control of developments in the flood plain of the French Broad River and Spring Creek, and in reaching decisions on the magnitude of floods to consider for this purpose, appropriate consideration should be given to the possible future occurrence of floods of the magnitude of (1) those that have occurred in the past, (2) the Regional Floods derived from those that have occurred on streams of similar physical characteristics in the region of Hot Springs, and (3) the Maximum Probable Floods that it is estimated might occur.

This report should be useful in planning new developments in the flood plain. From the maps, profiles, and cross sections, the depth of probable flooding by either recurrence of the largest known historic floods or by occurrence of the Regional or Maximum Probable Floods at any location may be ascertained. Having this information, floor levels for buildings may be planned either high enough to avoid flood damage or at lower elevations with recognition of the chance and hazards of flooding that are being taken.

I.

RESUME

OF

FLOOD SITUATION

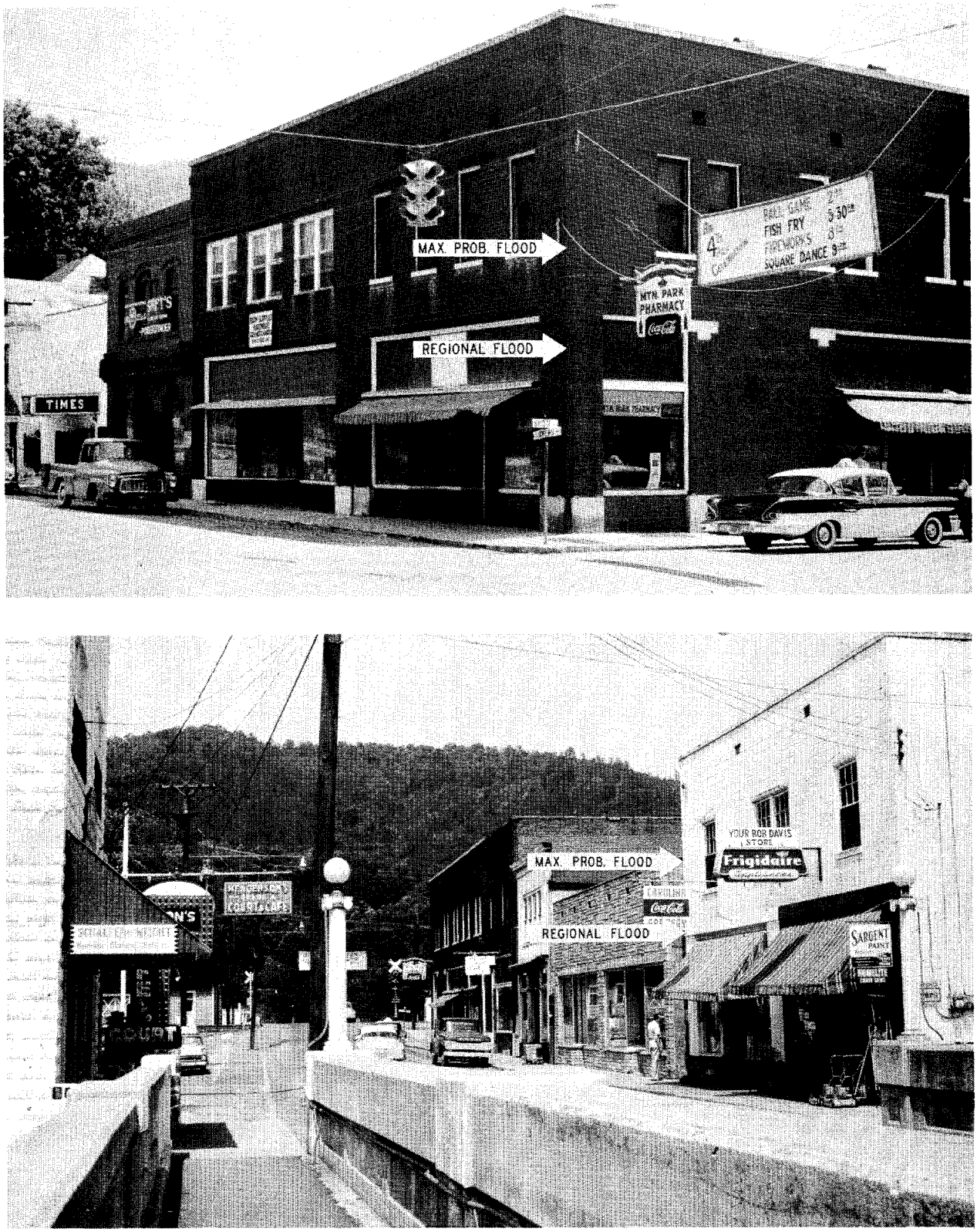


Figure 1. --MAXIMUM PROBABLE AND REGIONAL FLOODS AT HOT SPRINGS

Upper view shows Andrew Avenue at Bridge Street from railway depot. Lower view shows Bridge Street, U. S. Highways 25 and 70, from Spring Street bridge toward Southern Railway. Arrows show heights of the Regional Flood and Maximum Probable Flood discussed in Sections III and IV.

Tennessee Valley Authority
Division of Water Control Planning

I.

RESUME OF FLOOD SITUATION

Hot Springs, North Carolina, is located on the French Broad River about 109 miles above the mouth and about 7 miles above the Tennessee - North Carolina state line. The corporate limits extend for five miles along the river, but the greater part of the town is situated on the left bank near the center of this reach at the confluence of the river and Spring Creek. The river watershed above the developed section of the city covers 1565 square miles, and the watershed of Spring Creek above its mouth covers 72 square miles.

Much of the flood plain of the river in the Hot Springs vicinity is agricultural land. Only a small part of the business and residential section has been inundated by historical floods, but a substantially greater area in the city is within reach of greater floods of the future. Most of this area is in the combined flood plains of Spring Creek and the river. By far the largest overflow experienced since the town was incorporated 74 years ago was that during the record French Broad River flood of July 1916. Large headwater floods of the past on Spring Creek have caused no significant damage.

Records of water levels on the French Broad River at Hot Springs have been maintained at various locations since May 1934. There are no such records on Spring Creek. In compiling a record of early floods it has been necessary to interview residents along the river who have knowledge of these floods and to conduct research in newspaper files and historical documents. From these investigations and from studies of possible future floods on the French Broad River and Spring Creek in the Hot Springs vicinity, the flood situation, both past and future, has been developed. The following paragraphs summarize the significant findings with regard to the flood situation which are described in more detail in succeeding sections of this report.

THE GREATEST FLOOD in more than 169 years on the French Broad River in the Hot Springs vicinity occurred on July 16, 1916. This flood washed away the highway bridge at Hot Springs, damaged crops, and inundated several homes and business places. The greatest known headwater floods on Spring Creek were those of August 30, 1940, and June 16, 1949, which were of about equal height. Backwater from the river in 1916 exceeded the height of these headwater floods in the lower 0.4 mile of Spring Creek.

* * *

OTHER BIG FLOODS reaching within 3 to 6 feet of the 1916 crest on the French Broad River occurred in March 1867, June 1876, February 1902, and on August 30, 1940. On Spring Creek a flood in April 1896 may have been as high as the 1940 and 1949 crests.

* * *

A REGIONAL FLOOD on the French Broad River at Hot Springs, based on floods experienced on streams within 100 miles of Hot Springs, would have a peak discharge approximately 10 percent greater than the record flood of 1916 and would reach stages up to 3 feet higher than in 1916. On Spring Creek the headwater Regional Flood would be 10 to 18 feet higher than the 1940 flood. This headwater flood would be higher than backwater from the Regional Flood on the river except at the mouth of the creek. (See Figure 1)

* * *

MAXIMUM PROBABLE FLOOD determinations indicate that floods could occur on the French Broad River at Hot Springs 8 to 12 feet higher than the 1916 flood. On Spring Creek the Maximum Probable Flood would be 18 to 21 feet above the 1940 flood. Backwater from the Maximum Probable Flood on the river would exceed the height of the Maximum Probable Flood on the creek only below Mile 0.24. Floods of this magnitude on the two streams could be expected to occur only rarely. (See Figure 1)

* * *

FLOOD DAMAGES that would result from a flood as large as that of 1916 on the river would be substantial under present-day conditions of development at Hot Springs. Such a flood, with its deep overflow and high velocities, would inundate much of the flood plain to depths of as much as 15 feet, destroying crops, flooding homes, business places, and city offices, and damaging roads and the Southern Railway tracks. Floods occurring on Spring Creek since incorporation of the city have not caused serious damage. The Regional and Maximum Probable Floods on the two streams, with their great depths and high velocities, would cause much greater damage.

* * *

MOST FREQUENT FLOOD OCCURRENCES on the French Broad River at Hot Springs have been in the winter and early spring. However, many of the higher floods of the past have occurred between June and August. These great summer floods have resulted from tropical hurricane storms and intense widespread thunderstorm activity. On Spring Creek, floods occur in both winter and summer with many of the larger floods resulting from intense summer thunderstorm activity.

* * *

CHARACTERISTICS OF THE WATERSHED of the French Broad River above Hot Springs are such that serious flooding can result from storms concentrated in the 620-square-mile area between Asheville and Hot Springs, as well as from widespread storms. This local area contributed greatly to the flood peak of August 30, 1940. Also important in its effect on flood heights at Hot Springs is the natural storage of flood waters resulting from the flat channel slope and wide flood plain of the French Broad River upstream from Asheville.

* * *

OBSTRUCTIONS TO FLOW are not significant in the river flood plain in the Hot Springs vicinity. In the Spring Creek flood plain, however, a serious obstruction to very high headwater flood flows would result from the buildings and bridge along Bridge Street between Andrew Avenue and Spring Street and from the bridge, railroad fill, and buildings along Andrew Avenue.

VELOCITIES OF WATER averaged 10 to 15 feet per second in the channel of the French Broad River during the July 1916 flood. On the flood plain, velocities ranged up to 6 feet per second. On Spring Creek the channel velocities in 1940 and 1949 were in the order of 10 to 12 feet per second. During the Maximum Probable Flood on the river, velocities in the channel would range up to 29 feet per second and on the flood plain up to 10 feet per second. Spring Creek velocities during a Maximum Probable Flood would be 8 to 24 feet per second in the channel and up to 14 feet per second through the streets and around buildings in the flood plain.

* * *

DURATION OF FLOODS at Hot Springs is relatively short on the river and Spring Creek. The August 30, 1940, flood on the river was above bankfull stage for 27 hours. This flood rose at an average rate of nearly 1 foot per hour. The average rate of rise during the 1916 flood was about double this rate. Floods of the magnitude of the Maximum Probable Flood on the river would rise some 33 feet from low water to the crest stage in about 12 hours, and the maximum rate of rise would be about 5 feet per hour. On Spring Creek the Maximum Probable Flood would rise 29 feet in about 7 hours with a maximum rate of 8 feet per hour.

* * *

EXTREMELY HAZARDOUS CONDITIONS may be expected during large future floods on the two streams and especially along Spring Creek. Most of the business section of Hot Springs along Andrew Avenue and Bridge Street would be flooded either by the river or by swift headwater flows from the creek. Water along Andrew Avenue and Bridge Street would be up to 18 feet deep. Water would be as much as 15 feet deep over the Southern Railway tracks. Many buildings would be damaged or swept away by high velocities, endangering the lives of their occupants.

* * *

FUTURE FLOOD HEIGHTS that would be reached if floods of the magnitudes of the Regional and Maximum Probable occurred on the French Broad River and Spring Creek are shown in Table 1. This table compares these future flood crests with the crest of the 1916 flood on the French Broad River at U. S. Highway 25 and 70 bridge and with the crest of the 1940 flood on Spring Creek at Bridge Street bridge.

* * *

TABLE 1

RELATIVE FLOOD HEIGHTS

AT HOT SPRINGS

Flood	Location	Mile	Estimated Peak Discharge cfs	Above 1916 or 1940 Flood feet
	French Broad River			
1916	Above U. S. Highway 25-70	108.92	110,000	0
Regional			120,000	0
Maximum Probable			215,000	11.2
	Spring Creek			
1940	Above Bridge Street	0.38	6,300	0
Regional			28,000	14.6
Maximum Probable			55,000	20.3

II.

PAST FLOODS

Tennessee Valley Authority
Division of Water Control Planning
Hydraulic Data Branch

II.

PAST FLOODS

This section of the report is a history of floods which have occurred on the French Broad River and Spring Creek in the vicinity of Hot Springs, Madison County, North Carolina. The 7-mile portion of the river considered extends from the Southern Railway bridge at Hot Springs, river Mile 110, downstream to the vicinity of Paint Rock, North Carolina, at river Mile 103, which is 3 miles below the lower city limits. On Spring Creek the investigation covers the lower 1.9 miles of the stream, all of which is within the corporate limits of the city.

The French Broad River flows generally northwestward through Hot Springs. The region is mountainous, and bottomlands along the stream are relatively narrow. The developed portion of the Hot Springs corporate area is situated largely on the south side of the river and on both sides of Spring Creek, which flows northward in the city. The Hot Springs business district, a large resort hotel, one industrial plant, and several homes are located within reach of large floods on the river or creek.

Records of flood crest stages on the French Broad River at Hot Springs began in May 1934 when the U. S. Geological Survey established a recording gage on the right bank at Mile 109.20. The U. S. Weather Bureau established a non-recording gage at the old U. S. Highway 25-70 bridge in September 1934. This gage, moved in February 1952 to the new bridge, is still in operation. The U. S. Geological Survey records were discontinued in September 1949. There is no record of stream stages and discharges on Spring Creek except for a non-recording gage operated for low-flow measurements in 1944-1945. Flood history investigations made along the entire French Broad River by TVA Hydraulic Data Branch engineers in 1937 developed information on early floods on the river. Field investigations have been made immediately following all significant floods on the river since that time. Local residents have been interviewed and a search made of newspaper files and historical records.

From these sources it has been possible to develop a history of known large floods on the French Broad River covering the past 169 years and on Spring Creek covering the past 65 years or more.

FRENCH BROAD RIVER VALLEY

Settlement

Madison County was formed in 1851 from a part of Buncombe and Yancey Counties. Hot Springs, located near the northwestern edge of the county, was incorporated in 1886.

The natural springs from which the town derives its name were discovered in 1778. The early settlement, known as Warm Springs, centered about the springs, and the first hotel, built in the 1830's, became widely known as a resort. As many as 600 people are reported to have stayed at the resort at one time during the peak of its popularity.

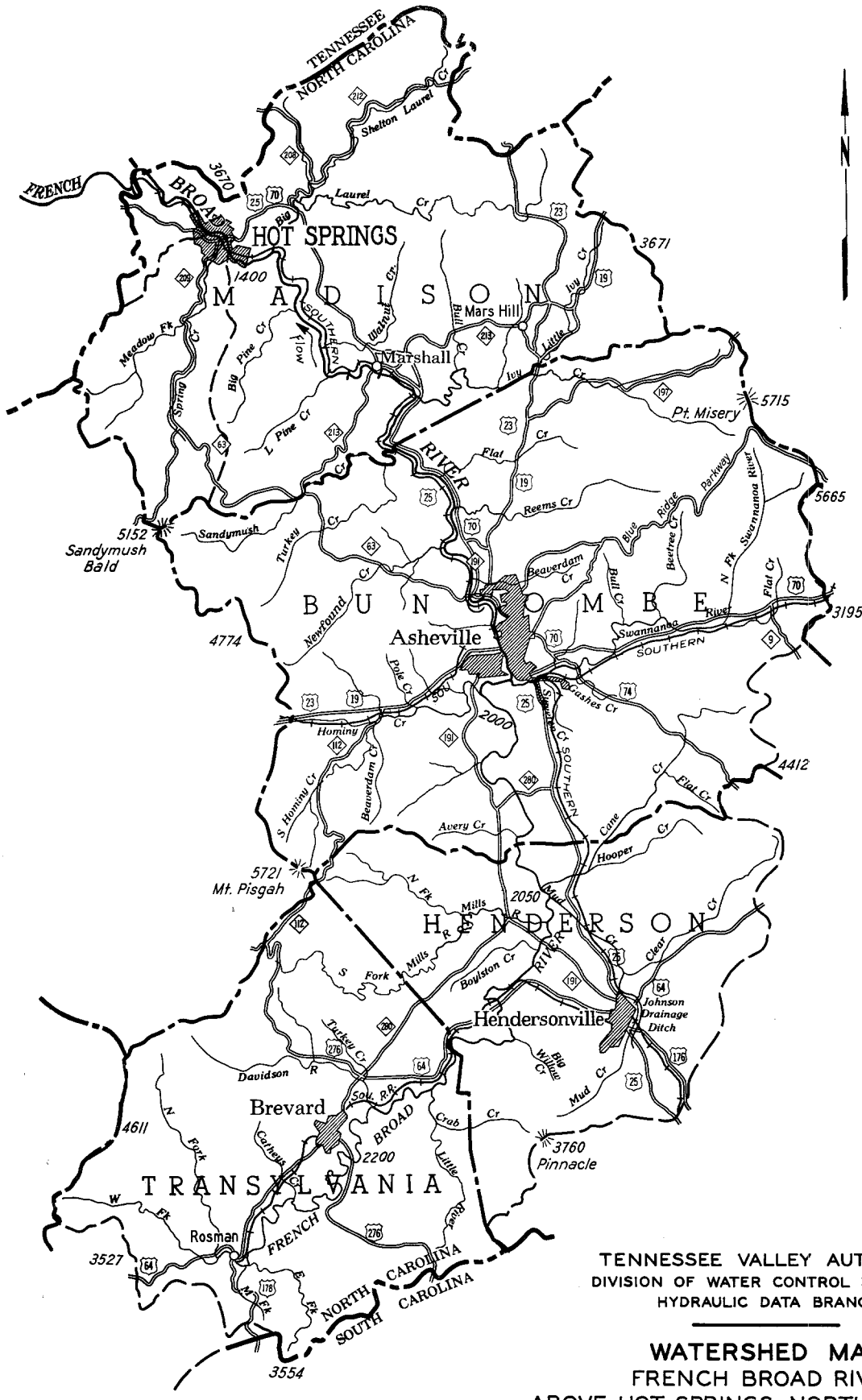
The Western North Carolina Railroad, now the Southern Railway's Asheville Branch, was completed to the Tennessee state line in January 1882, connecting Asheville, Marshall, and Hot Springs to the railroad from Knoxville.

The 1950 census lists a population of 721 for Hot Springs.

The Streams and Their Valleys

The French Broad River basin covers an area of 5, 124 square miles in North Carolina and Tennessee. The portion of the basin above the highway bridge at Hot Springs, shown in Plate 1, is about 70 miles long by an average 22 miles wide, with a total area of 1565 square miles. The river has its origin along the north and west slopes of the Blue Ridge which divides the Tennessee River Basin from the Atlantic Coast drainage. The mountainous watershed above Hot Springs lies within the four North Carolina counties of Transylvania, Henderson, Buncombe, and Madison. Approximately 75 percent of the area is forest-covered.

The French Broad River proper begins at Rosman near the base of the Blue Ridge and about 55 miles south of Hot Springs. From Rosman to Asheville, which is about 40 river miles upstream from Hot Springs, it follows a meandering course through a broad flood plain with an average channel slope of about 3



TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

WATERSHED MAP
FRENCH BROAD RIVER
ABOVE HOT SPRINGS, NORTH CAROLINA

Scale 0 10 20 Miles

JULY 1960

ASF-1311

feet per mile, much flatter than is usual for a mountain area stream. The wide bottoms in this reach provide substantial natural storage of flood waters which has a significant effect on timing and height of floods at Hot Springs. This is particularly true of the floods resulting from large headwater storms such as those of July 1916, August 1928, and August 1940. The watershed between Asheville and Hot Springs, draining 620 square miles, is more mountainous and the river flows in a narrow gorge with little bottomland and steep channel slopes. The average fall from Asheville to Hot Springs is about 17 feet per mile.

In the Hot Springs vicinity the average fall from Mile 110 to 103 is 11.7 feet per mile. However, there is a pronounced break in slope at about the mouth of Spring Creek, the average fall above this point being about 18.5 feet per mile and below it about 9.7 feet per mile.

The long, narrow, and mountainous Spring Creek watershed extends southward some 15 miles from Hot Springs with an average width of about 5 miles. The entire basin is in Madison County, and the county line forms most of its southern and western boundary. The stream heads on Sandymush Bald, elevation 5, 152 feet, the junction of Madison, Buncombe, and Haywood Counties. The elevation at the confluence with the French Broad River is about 1, 300 feet. The fall of the creek channel in the 1.9 miles within the corporate limits of Hot Springs averages 58 feet per mile. During floods of the magnitude of the 1916 flood on the French Broad River, backwater from the river extends about 0.7 mile up Spring Creek.

Pertinent drainage areas in the vicinity of Hot Springs are given in Table 2.

The character of the French Broad River basin above Hot Springs is such that damaging floods on the river can result not only from general storms which affect the whole basin but also from storms centered primarily on the part of the basin between Asheville and Hot Springs. Because of the influence of this 620-square-mile area from which runoff concentrates rapidly, flood peaks may occur at Hot Springs before they occur at Asheville. On August 30, 1940, when rainfall was heavy over this area, the crest stage at Hot Springs occurred 4 hours before that at Asheville and some 10 to 24 hours before the crest in the flat reach above Asheville.

TABLE 2

DRAINAGE AREAS IN WATERSHED OF FRENCH BROAD RIVER

Stream	Location	Mile Above Mouth	Drainage Area sq. mi.
French Broad River	Asheville	145.8	945
	Hot Springs -		
	Southern Railway bridge	110.0	1561
	USGS gage	109.2	1563
	U. S. Highway 25-70	108.9	1565
	Below Spring Creek	108.5	1639
	Paint Rock	103.0	1663
Spring Creek	Hot Springs -		
	N. C. Highway 209	1.2	70.8
	Bridge Street	0.4	71.9
	Mouth	0.0	72.0

The corporate limits of Hot Springs include the left side of the French Broad River from Mile 105.94 to Mile 110.98 and the right side from Mile 106.92 to Mile 110.98. Most of the urban development is south of the river between Miles 107.8 and 109.2 and west of Spring Creek between the mouth and Mile 1.2. Much of it is on high ground above flood danger. However, the entire business district along Andrew Avenue and Bridge Street is in the area that would be reached by very large floods of the future, together with a number of homes and churches, one industry, and the Hot Springs Inn.

Flood plain widths along the river are greatest on the left bank in the immediate vicinity of the town, ranging up to 1000 feet between Highway 25-70 bridge and the mouth of Spring Creek. From about Mile 109.7 upstream the flood plain is very narrow. Below Mile 108 the flood plain shifts from one side of the river to the other and rarely exceeds 600 feet in width.

Spring Creek has little or no flood plain above Mile 0.6. Below this point the wider bottom lands are those which the creek shares with the river.

Developments in the Flood Plain

Plate 7 shows the flood plain of the French Broad River and Spring Creek in the Hot Springs vicinity as defined by the overflow limits of the greatest known and Maximum Probable Floods. Plate 8 shows in more detail the flood plain developments at Hot Springs.

Except for the immediate Hot Springs area the use of the flood plain is almost entirely limited to agriculture. The Southern Railway's Asheville Branch tracks follow the left edge of the flood plain from Mile 103 upstream to the bridge at Mile 110 and shift to the right edge above the bridge. During the 1916 flood the tracks were overtopped for a considerable part of the lower 3 miles of the reach. Depths of flooding over the top of rails ranged up to 4 feet. The Maximum Probable Flood, described in Section IV of this report, would overtop the railroad in practically the entire 7-mile reach to depths up to 15 feet.

A few homes are located in the flood plain outside of the Hot Springs area, principally in the Paint Rock vicinity.

In Hot Springs, the business section of the city is situated along the west side of Andrew Avenue, which runs north and south parallel to the railroad, and along both sides of Bridge Street which runs east and west and which is also the route of U. S. Highways 25 and 70. On Andrew Avenue North are located the town hall and clerk's office, fire department, library, post office, a beauty shop, and filling station. On Andrew Avenue South are a drug store, hardware and farm supply stores, and a theater. Floor elevations on Andrew Avenue North range from 1324.9 in the clerk's office to 1328.6 at the filling station. Floor levels in the Andrew Avenue South block of buildings are all at elevation 1330.1 to 1330.3.

Along the south side of Bridge Street westward from Andrew Avenue to Spring Street are a cafe, news stand, bank, general merchandise store, grocery, automobile parts store, and a furniture store with a barber shop in the rear. Floor levels in these business places range from elevation 1328.2 to 1330.1. Across the street on the north side are a cafe, tourist court, hardware store, and grocery, with floor levels between elevation 1324.3 and 1329.4. Several homes are located in this vicinity, one of which is reported to be the oldest house in Hot Springs. Floor level of this house, located near the Andrew Avenue bridge, is at elevation 1324.3. Although all of these buildings are in the flood plain of

Spring Creek, the greatest known overflow of the past in this vicinity has been that resulting from French Broad River backwater in July 1916. This backwater was at elevation 1327 upstream from the Andrew Avenue bridge. Headwater flood levels between Andrew Avenue and Bridge Street on Spring Creek ranged from elevation 1321 to 1325 during the floods of August 1940 and June 1949. Backwater from the Maximum Probable Flood on the river would overtop the railroad east of the business section and would reach an elevation of 1339 in this vicinity. The Maximum Probable Flood level along the creek would range from elevation 1342 just above Andrew Avenue bridge to 1346 just above Bridge Street bridge.

Farther west along Bridge Street and along the intersecting Spring Street and Meadow Lane are a tourist court, restaurant, two churches, and 15 or more homes with floor elevations ranging from 1329 to 1335. These are located well above the level of historic floods on the river and creek but would be inundated by the great floods of the future.

Between the railroad and the river on Highways 25 and 70 are a service station with floor at elevation 1331.2 and a clinic with floor at elevation 1327.0. The 1916 flood crest at the location of these buildings was elevation 1331. The Maximum Probable Flood on the river would reach elevation 1343 at the service station and 1341 at the clinic.

The Hot Springs Inn is located about 1000 feet downstream from the highway just upstream from the confluence of Spring Creek and the river. The original resort hotel here was built in the 1830's and destroyed by fire in 1884. A new hotel was built in 1886. This hotel burned down and the present structure was built in about 1928. The ground floor of the hotel is at elevation 1337.3 which is 9.3 feet higher than the 1916 flood level. The adjoining bath house, however, is on low ground near the river bank and the floor level at elevation 1312.8 is 15.2 feet lower than the 1916 flood crest. The old bath house was washed away in 1916.

About 15 homes are located near the right-bank end of the U. S. Highway 25 and 70 bridge, 10 of which are at or below the level of the 1916 flood. The floor of one house is 7.7 feet below the 1916 flood level. All would be inundated by a flood of the magnitude of the Maximum Probable.

The only industry in the flood plain is the Garland Lumber Company plant, situated between the railroad and the left river bank at about Mile 108.1. Established about 14 years ago at the site of an older plant, the plant buildings,

spur track, and principal lumber storage yard are some 5 to 13 feet above the 1916 flood level. However, a considerable amount of lumber is being stored in the low bottoms toward the river from the plant and this would be reached by a repetition of the 1916 or 1940 floods on the river. A Maximum Probable Flood would flood the buildings and seriously damage stored lumber. Elevations at the plant are as follows:

Sawmill floor	1337.9
Base of Diesel motor	1330.1
Planing mill floor	1330.0
Office floor	1332.0
1916 flood	1324.7
Regional Flood	1325.5
Maximum Probable Flood	1336.2

On Spring Creek there is little development upstream from the business district that would be affected by headwater floods. At Mile 0.6 a raw water pumping station, located on the right bank of the creek, is used to supply water from the creek for cooling and fire protection to Pacific Mills, which is above the flood plain. The floor of the pumphouse is at elevation 1341.9 and the critical elevation at which switches would be affected is 1 foot higher. The 1940 and 1949 headwater floods here reached elevation 1335. The Maximum Probable Flood crest would be at elevation 1351.5. At the same location, about 120 feet downstream from this pumping station, is a booster pump to supply city water to Pacific Mills. The electric motor would be damaged by water levels above elevation 1342.7.

The Hot Springs water supply system is generally above flood danger. However, there is an auxiliary supply pumping station at Bubbling Springs, on the left side of the river at Mile 106.95, that is reached by large floods. The base of the motors is at elevation 1304.5 which is the elevation at which damage would occur. The floor of the pumphouse is at elevation 1311.4. The July 1916 flood crest here was at about elevation 1311.4, and the Maximum Probable Flood would be 8 feet higher.

Hot Springs has no sewage treatment plant.

Bridges Across the Streams

The French Broad River is crossed by a highway bridge and a railroad bridge in the Hot Springs vicinity. Four highway bridges and a railroad bridge cross Spring Creek in the lower 1.9 miles considered in this investigation. Table 3 lists pertinent elevations on these structures. Figure 2 shows several of the bridges in the Hot Springs vicinity.

TABLE 3

BRIDGES IN VICINITY OF HOT SPRINGS, NORTH CAROLINA

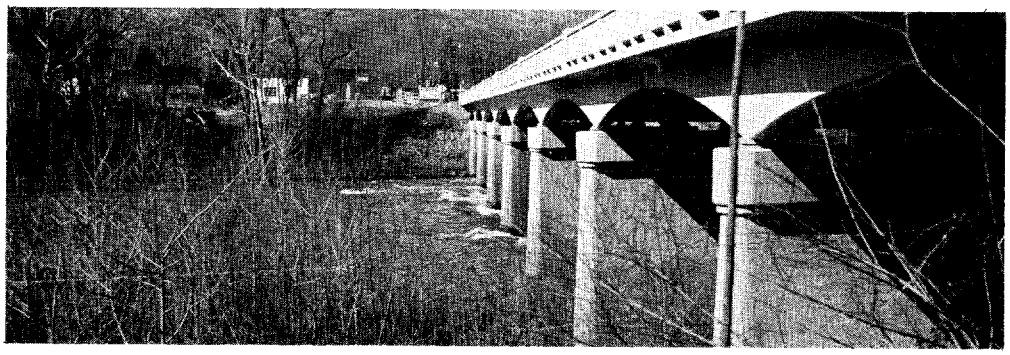
Mile Above Mouth	Identification	Low Water Elev. feet	Floor Elev. feet	(a) Flood Crest feet	Underclearance Elev. feet	Above Flood feet	Below Flood feet
			French Broad River				
108.92	U. S. Highway 25-70	1309.2	1338.4	1331.2	1335.5	4.3	
109.95	Southern Railway	1330.0	1355.9[b]	1346.5	1351.1	4.6	
			Spring Creek				
0.24	Southern Railway	1312.6	1331.8[b]	1328.5	1325.8		2.7
0.25	Andrew Avenue	1312.8	1326.4	1328 5	1325.4		3.1
0.38	Bridge Street	1316.9	1328.7	1328.5	1326.2		2.3
1.19	N. C. Highway 209	1353.6	1381.1	1365.0	1376.8	11.8	
1.90	N. C. Highway 209	1414.5	1431.6	1419.0[c]	1430.6	11.6	

(a) 1916 flood on French Broad River and 1916 backwater up to Mile 0.4 on Spring Creek. August 30, 1940, flood on Spring Creek above Mile 0.4.

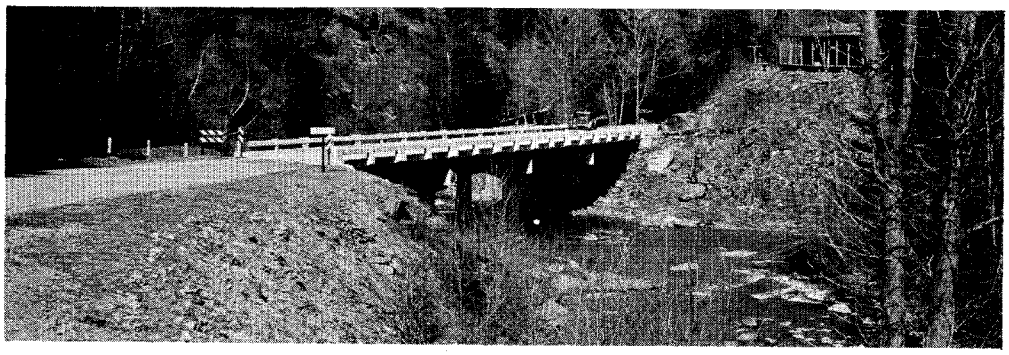
(b) Top of rail.

(c) Approximate.

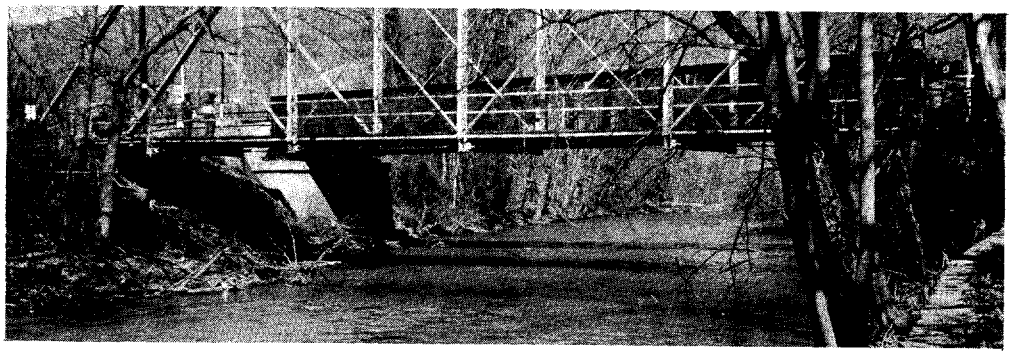
The concrete highway bridge at Mile 108.92 was completed in 1952 to replace a two-span steel truss bridge located at Mile 108.87. The floor of the old bridge was level at about elevation 1333 whereas the floor of the new bridge rises from elevation 1333.9 at the left end to elevation 1344.5 at the right end. The clear opening under the old bridge was about 300 feet with one center pier. The new bridge is 538 feet long and it is supported on 7 piers. The July 1916 flood washed away the bridge at Mile 108.87.



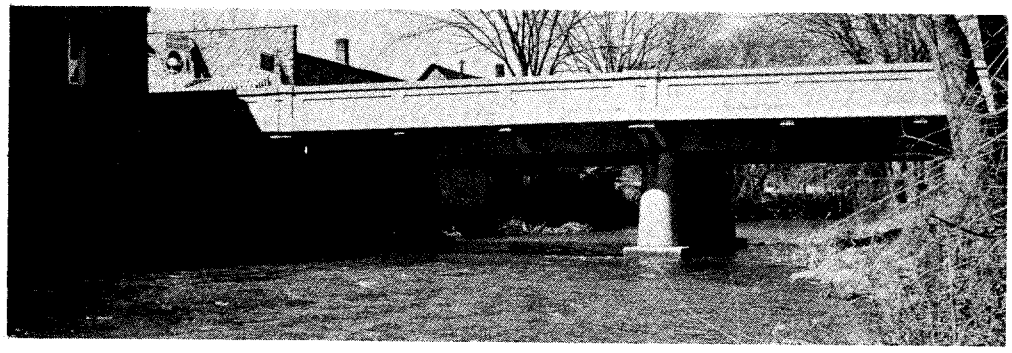
U. S. Highways 25 and 70 bridge across French Broad River



State Highway 209 bridge across Spring Creek



Andrew Avenue and Southern Railway bridges across Spring Creek



Bridge Street bridge across Spring Creek

Figure 2. --RIVER AND CREEK BRIDGES AT HOT SPRINGS

There has been no change in many years at the Southern Railway bridges across the river at Mile 109. 95 and across Spring Creek at Mile 0. 24, or at the Andrew Avenue bridge, Mile 0. 25.

The present concrete bridge across Spring Creek at Bridge Street was built in 1923, replacing an old bridge at the same location. The old bridge floor was reported by local people to have been 1 foot under river backwater at the crest of the 1916 flood.

The two highway bridges across Spring Creek at Miles 1. 19 and 1. 90 were built in about 1955. An old bridge across the creek at Mile 1. 6 has been removed.

Obstructions to Flood Flows

There are no serious obstructions to the flow of floods as high as that of 1916 along the French Broad River in the Hot Springs vicinity. The new highway bridge and the railroad bridge appear to have ample opening except for the most extreme floods. The railroad is situated at the edge of the flood plain and does not restrict the floodway.

On Spring Creek the bridge and buildings along Bridge Street between Spring Street and the railroad would cause a serious obstruction to a very large headwater flood. These structures block most of the flood plain on the right side of the creek. Buildings along Andrew Avenue together with the railway fill and bridge add to the obstruction farther downstream. Upstream from the Bridge Street vicinity there has been little infringement on the floodway.

FLOOD SITUATION

Flood Records

The U. S. Weather Bureau has maintained a stream gage at Hot Springs since September 6, 1934. The original station was a wire weight gage located on the old highway bridge at Mile 108. 87. On February 7, 1952, the gage was moved to the new bridge at Mile 108. 92. The U. S. Geological Survey established a recording gage on the right side of the river at Mile 109. 20 on May 16, 1934. This gage was terminated by the Survey on September 30, 1949.

No records of stream stages have been maintained on Spring Creek. The Geological Survey maintained a staff gage at Mile 0.58 during 1944 and 1945 but no continuous observations were made.

Data on floods on the river at Hot Springs prior to 1934 and on Spring Creek have been obtained from interviews with local residents who witnessed or had knowledge of the floods, from newspaper files in Asheville and Marshall, the county seat, and from a search of historical documents and records. Reports of field investigations made by the Hydraulic Data Branch during the last 25 years have supplied valuable data. Chief among these was an investigation of the flood history of the French Broad River made in 1937 and an investigation of the August 1940 floods.

Flood Stages and Discharges

Peak stages of the French Broad River are given in Table 4 for known floods exceeding bankfull stage at the Geological Survey and Weather Bureau gages at Hot Springs. Bankfull stage is 13 feet referred to the Weather Bureau gage and 8 feet referred to the Geological Survey gage. At these stages flooding occurs in the vicinity of the confluence of the river and Spring Creek and on bottoms downstream from the central part of Hot Springs.

For the period prior to 1934, flood crest stages are estimated from previous flood height investigations made at Asheville, Marshall, and Newport and stage relationship curves between these locations and Hot Springs. The July 16, 1916, crest stages at both gages are from high water marks and the high water profile. Discharges are listed in the tabulation only for the 1916 flood and for the floods occurring during the period 1934-1949 when the Geological Survey gage was operated.

Based on these estimations of the heights of the large floods prior to 1934, the highest 5 floods on the French Broad River at Hot Springs were those shown in Table 5. Stages are referred to the old site of the Weather Bureau gage, Mile 108.87.

TABLE 4

FLOOD CREST ELEVATIONS AND DISCHARGES ABOVE BANKFULL STAGE

FRENCH BROAD RIVER AT HOT SPRINGS, NORTH CAROLINA

This table includes all floods recorded since May 16, 1934, that exceeded bankfull stage of 8 feet at the U. S. Geological Survey gage or 13 feet at the U. S. Weather Bureau gage. Prior to 1934 the records are necessarily incomplete. Drainage areas: at USGS gage 1563 square miles; at USWB gage 1565 square miles. Zero elevations: at USGS gage 1311.55; at USWB gage 1302.25, both USC and GS 1936 Supplementary Adjustment.

Date of Crest	At USGS Gage				At USWB Gage*	
			Peak Discharge			
	Stage feet	Elevation feet	Amount cfs	Per Sq. Mi. cfs	Stage feet	Elevation feet
April 1791	-	-			-	-
August 1796	12	1324			18	1320
1810	10	1322			16	1318
May 1845	12	1324			18	1320
August 1850	11	1323			17	1319
August 1852	14	1326			20	1322
March 1867	18	1330			24	1326
June 17, 1876	17	1329			23	1325
June 1892	8	1320			13	1315
September 13, 1893	8	1320			13	1315
March 15, 1899	8	1320			13	1315
March 19, 1899	8	1320			13	1315
May 22, 1901	8	1320			13	1315
December 29, 1901	8	1320			13	1315
February 28, 1902	19	1331			25	1327
January 23, 1906	8	1320			13	1315
August 31, 1910	9	1321			15	1317
July 11, 1916	8	1320			13	1315
July 16, 1916	22	1333.6	110,000	70	28.6	1330.9
August 16, 1928	12	1324			17	1319
January 19, 1936	8.75	1320.3	38,600	25	14	1316
August 14, 1940	9.07	1320.6	37,100	24	15.2	1317.4
August 30, 1940	16.1	1327.6	75,900	49	22.4	1324.7
January 7, 1946	10.0	1321.6	43,500	28	16	1318
February 10, 1946	9.20	1320.8	38,900	25	15	1317
January 22, 1954	8	1320			14.25	1316.5
February 1, 1957	9	1321			15.65	1317.9
April 5, 1957	12	1324			19.25	1321.5

*U. S. Weather Bureau stages after February 1952 are at the new highway bridge, Mile 108.92, and are higher because of slope of the river than equivalent stages at the old bridge site, Mile 108.87.

TABLE 5

HIGHEST 5 FLOODS IN ORDER OF MAGNITUDE

FRENCH BROAD RIVER AT HOT SPRINGS

AT U. S. WEATHER BUREAU GAGE, MILE 108.87

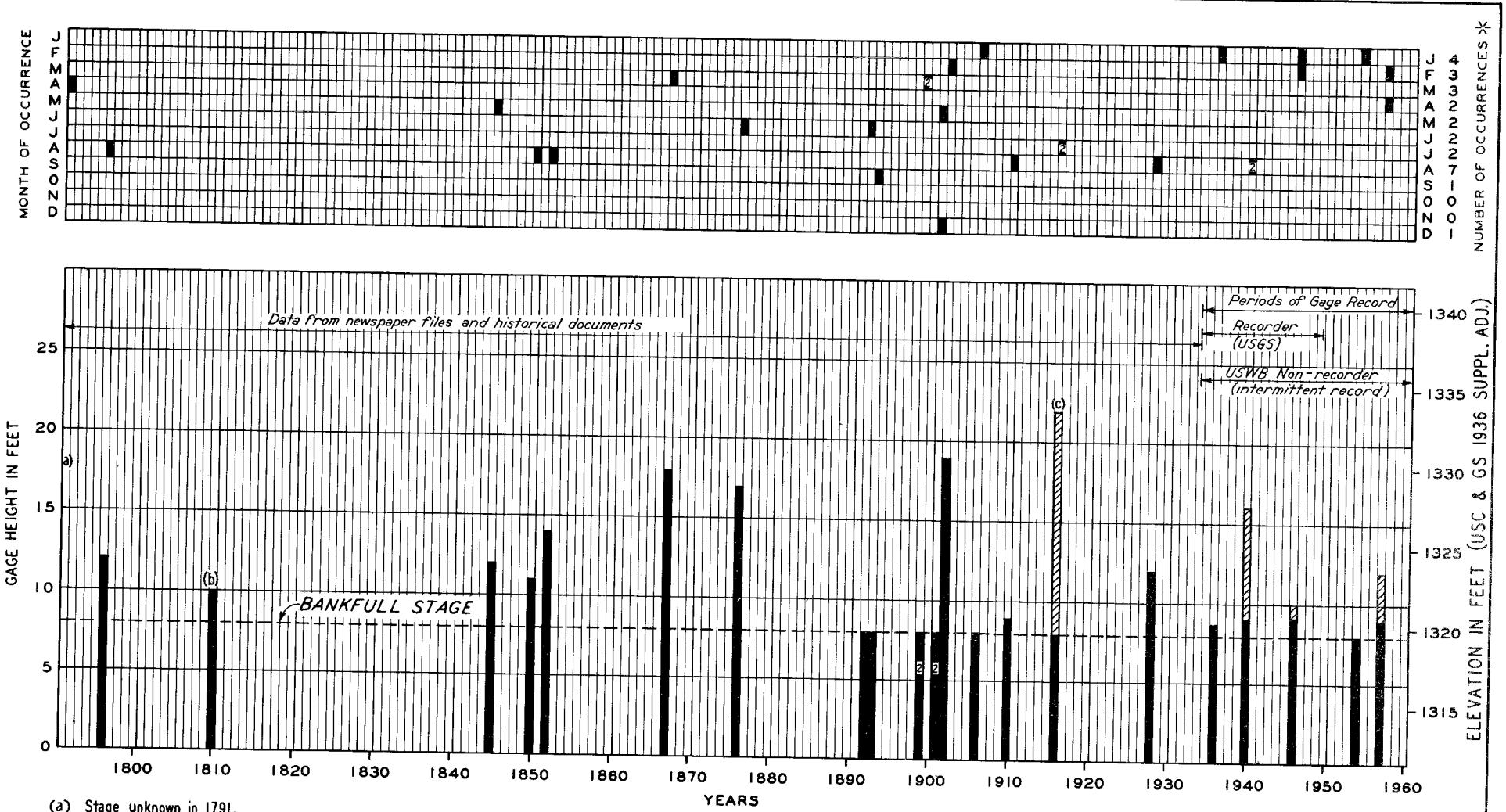
Order No.	Date of Crest	Gage Height	
		Stage feet	Elevation feet
1	July 16, 1916	28.6	1330.9
2	February 28, 1902	25	1327
3	March 1867	24	1326
4	June 17, 1876	23	1325
5	August 30, 1940	22.4	1324.7

No data are available to prepare a list of the headwater floods on Spring Creek. Local people recalled large floods in April 1896, February 1902, April 1920, August 15 and 30, 1940, June 1947, June 1949, and other dates. The largest flood on the creek in the last 65 or more years was that of June 1949 although the high water marks show that the 1940 flood was probably of about the same height. Several older people thought the flood in April 1896 was the greatest known on the creek.

A determination of the peak discharge of the August 30, 1940, flood on Spring Creek was made by the U. S. Geological Survey at Mile 1.3. The discharge thus determined was 6,300 cubic feet per second for a drainage area of 71.5 square miles or 88 cubic feet per second per square mile.

Flood Occurrences

Plate 2 shows crest stages and months of occurrence of known floods which have exceeded bankfull stage of 8 feet at the Geological Survey stream gage on the French Broad River at Hot Springs. Table 6 shows the monthly distribution of 27 known floods occurring in the past 169 years.



(a) Stage unknown in 1791.

(b) Month unknown.

(c) Stage based on high water marks.

All stages are referred to USGS gage which was located at Mile 109.20, upstream from present USWB gage.

* Number of occurrences during 169 years 1791-1960, excluding 1810 flood.

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

FLOODS ABOVE BANKFULL STAGE

FRENCH BROAD RIVER AT HOT SPRINGS, NORTH CAROLINA

JULY 1960

PLATE 2

TABLE 6

MONTHLY FLOOD DISTRIBUTION

FRENCH BROAD RIVER AT HOT SPRINGS

Month	Number of Occurrences	Month	Number of Occurrences
January	4	July	2
February	3	August	7
March	3	September	1
April	2	October	0
May	2	November	0
June	2	December	1
		Total	27

Known flood occurrences have been about equally divided between the winter months January through March and the summer months June through August. However, at Marshall and Newport, where records are more complete, the data show a greater frequency of flood occurrences in the winter months than in the summer and this relationship must be true also at Hot Springs which is located between the other two stations. All three records show that floods occur on the river in practically every month of the year and that very large floods may occur in both winter and summer.

Spring Creek floods result from general winter storms and the more localized intense summer thunderstorms. Because of the location of the watershed some 50 miles north of the Blue Ridge, the stream is not affected to any great extent by decadent hurricane storms such as those of July 16, 1916, and August 15, 1940. The large floods of August 30, 1940, and June 16, 1949, were the result of heavy thunderstorm activity over a wide area.

Rate of Rise and Velocities During Floods

Plate 3 is a hydrograph for the large flood of August 30, 1940, on the French Broad River at the U. S. Geological Survey gage at Hot Springs. During this flood the river rose from a stage of 3 feet to the crest of 16.1 feet in 16 hours, an average rate of rise of 0.8 foot per hour. The maximum rate of rise was 2.3 feet between 3 a.m. and 4 a.m. on August 30. The crest occurred at 7:30 a.m. The river was above bankfull stage of 8 feet for 27 hours. Floods of the magnitude of the one in July 1916 or larger would rise at an even more rapid rate. At Marshall, less than 20 miles upstream from Hot Springs, the 1916 flood rose at an average rate twice as great as in 1940.

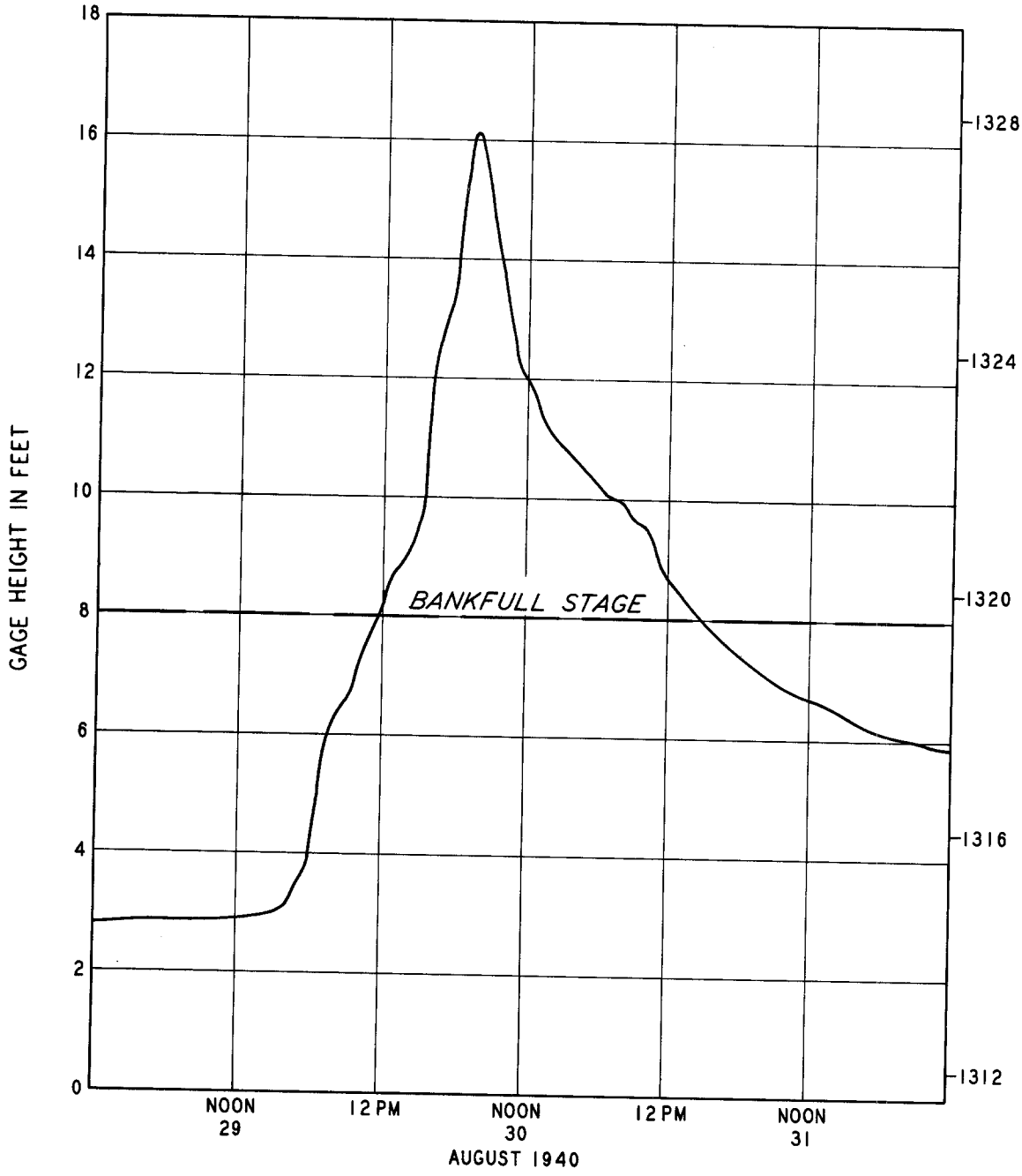
During the 1940 flood, average velocities in the channel of the French Broad River through the Hot Springs reach were in the order of 10 to 14 feet per second. In the flood plain, velocities ranged from 1 to 6 feet per second. In 1916, the channel velocities ranged up to 15 feet per second and flood plain velocities were in the order of 1 to 6 feet per second. During larger floods, velocities in both channel and overbank areas would be even greater.

On Spring Creek, the average velocity on August 30, 1940, was in the order of 10 to 12 feet per second. No data are available on the rate of rise of the creek, but the relatively small drainage area and the steep slopes of the watershed and stream channel are indicative of a rapidly rising stream.

Flooded Area, Flood Profiles, and Cross Sections

Plate 7 shows the approximate area in the Hot Springs vicinity that would be inundated by a recurrence of the 1916 flood on the river. Plate 8 shows the approximate 1916 flooded area in the business and residential section of Hot Springs. The actual limits of these overflow areas on the ground may vary somewhat from those shown on the maps because the contour interval of the topographic map, Plate 7, which is 40 feet, does not permit precise plotting of the flooded area boundaries. At the time of the 1916 flood, Spring Creek was not at a high stage and the flooding along the creek was a result of backwater from the French Broad River.

Plate 9 shows high water profiles on the French Broad River for the floods of July 16, 1916, and August 30, 1940. An inset on this plate shows the



Gage at Mile 109.20

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

STAGE HYDROGRAPH
FRENCH BROAD RIVER
AT HOT SPRINGS, N. C.

JULY 1960

ASF-1311

high water profile for the June 1949 flood on Spring Creek and high water marks for the flood of August 30, 1940, which was of about the same magnitude as the 1949 rise.

Plate 9 also shows, for each stream, profiles for the Regional Flood and the Maximum Probable Flood which are discussed in Sections III and IV, respectively.

Plate 10 shows typical cross sections of the valleys of the French Broad River and Spring Creek in the Hot Springs vicinity. The locations of the cross sections is shown on Plates 7 and 9. Each river cross section shows the elevation and extent of overflow of the floods of 1916 and 1940 and the Regional and Maximum Probable Floods. The Spring Creek cross sections show the elevation and extent of the 1949 flood and the Regional and Maximum Probable Floods on that stream and also of the river backwater. A number of cross sections, the locations of which are shown on the map and profiles, are not reproduced but are available from the Hydraulic Data Branch of TVA to anyone who has need for them.

FLOOD DESCRIPTIONS

Many large floods have occurred in the past on the French Broad River and Spring Creek. However, none of these except the one in 1916 has had any serious impact on Hot Springs. Even the record 1916 flood did not have the devastating effect in the Hot Springs vicinity that it had at Asheville, Marshall, and other localities along the river. For this reason, available material describing floods on the river or creek at Hot Springs is meagre. The following brief descriptions cover some of the larger floods.

French Broad River

Early Floods

F. A. Sondley, Asheville historian and philanthropist, in his book "Asheville," discussed some of the great early floods on the French Broad and Swannanoa Rivers. He mentions the "heavy freshets" of April 1791, 1810, and May 1845 and then adds:

> On August 28-30, 1852, a freshet had done considerable damage in the valley of these rivers and washed away on the French Broad the bridge . . . near the mouth of Hominy Creek, Smith's Bridge at Asheville, Garmons' Bridge at what is now Craggy, Alexander's Bridge at French Broad (now Alexander) and Chunn's Bridge and Warm Springs (now Hot Springs) Bridge in Madison County, ...

The 1852 flood was described in the Asheville "News" for September 2, 1852, as being "higher than it has been in many years before, exceeding largely the great flood two years ago."

Other large French Broad River floods in these early years occurred in August 1796 and August 1850.

March 1867

This was the greatest known flood on the lower French Broad River from Newport downstream, exceeding by an estimated 1.5 feet the July 1916 crest stage at Newport. Although no definite marks to establish the height of the 1867 crest could be found at Hot Springs, the flood must have ranked among the highest known there since less than 300 square miles of watershed drain into the river between the two localities.

June 17, 1876

At Asheville and above, the 1876 flood on the French Broad River ranked next below the record rise of 1916. The Signal Service Weather Observer at Asheville described the flood there as follows:

> The most prominent feature of this month was the large freshet on the 15th, 16th, and 17th. The height of the French Broad River in this and adjacent Counties was higher than it is remembered by the oldest inhabitants. . . . The river was the highest on the 17th noon, after having risen steadily the two days previous. . . . The oldest persons in the county cannot remember such a height of the French Broad, and several of them stated the river to have been 2 feet higher than ever before. . . . One man has been drowned at Marshall, Madison County.

The flood decreased in height as it moved downstream, but it would still have been a large flood at Hot Springs.

February 28, 1902

The 1902 flood was a major one at Hot Springs and over the whole length of the French Broad River at and below Asheville. At Marshall there was heavy damage to the town and to the Southern Railway tracks, indicating a flood at least as high as the one on August 30, 1940. Referring to the situation at Hot Springs the Asheville "Citizen" for March 3, 1902, reported as follows:

> At Hot Springs the track is washed out for great distances. A large number of buildings are washed away and several dwelling houses were carried off by the tide. The powerhouse and swimming pool at Mountain Park Hotel were washed away.
>
> The flood caused no interruption at Mountain Park Hotel. It is learned that no serious damage was done to the hotel building.

A local resident is quoted in the newspaper as follows:

> "It would be impossible," said Mr. A. V. Lawson of Hot Springs, "to describe the situation at Hot Springs. We have had no communication whatever with the outside world since the flood, not even had a newspaper."

At Newport the 1902 flood crest was about 0.5 foot higher than that of July 1916. It appears likely that it ranks second only to the 1916 flood at Hot Springs.

July 16, 1916

This was the greatest known flood on the French Broad River in North Carolina. It resulted from a tropical hurricane storm that passed inland over Charleston, South Carolina, on July 14 with winds of near hurricane intensity. The storm center advanced northwestward across South Carolina, losing much of its surface intensity but maintaining its intensity and high moisture content in the upper levels. Its path was affected by a high-pressure area over the northeastern states, and the heavily moisture-laden storm was directed toward the highest portion of the Blue Ridge which it was unable to cross because of insufficient energy.

The heaviest rainfall during the storm occurred along the Blue Ridge, particularly along the eastern boundary of the upper French Broad River watershed. Plate 4 shows the rainfall distribution over the watershed. Altapass,

North Carolina, recorded 23.7 inches for the storm, with 22.2 inches of this amount falling in 24 hours. Rainfall amounts decreased rapidly to the north and west of the Blue Ridge. Marshall recorded only 2.5 inches for the storm and Hot Springs only one-quarter inch.

Because of the tremendous damage suffered elsewhere along the French Broad River in North Carolina, there was little reference in the news accounts to the flood at Hot Springs. The August 4, 1916, edition of the "News-Record," published at Marshall, carried only the following brief mention of the flood at the city downstream.

> Hot Springs was not seriously hurt. The bridge there across the French Broad was washed away and the Mountain Park Hotel was flooded.

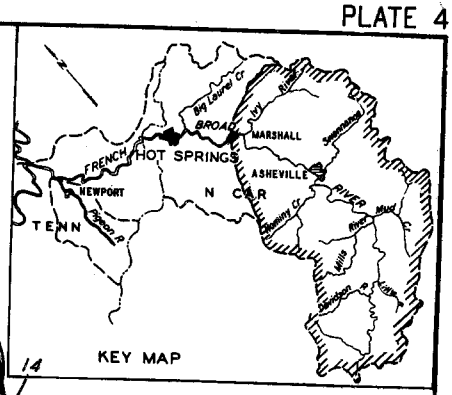
The comment about flooding at the hotel probably referred to auxiliary buildings on low ground riverward from the main building. The only flooding landward from the Southern Railway tracks in the developed portion of Hot Springs occurred between Andrew Avenue, Spring Street, and Bridge Street as a result of backwater in Spring Creek. This river backwater extended for about 0.7 mile up Spring Creek and exceeded the height of any known headwater flood on the creek in the lower 0.4 mile. Several of the buildings then in the area were inundated. At Paint Rock the river overflow reached within a foot or two of the first floor ceilings of several homes. Serious damage must have occurred to crops in the rich bottomlands along the river.

August 30, 1940

There were no floods of importance on the French Broad River at Hot Springs for the next 24 years after 1916. A flood on August 16, 1928, caused heavy damage above Asheville but at Hot Springs the Asheville "Citizen" for August 17, 1928, reported that little or no damage occurred.

The flood on August 30, 1940, was the fifth highest known on the river at Hot Springs. The flood resulted from extremely heavy and intense thunderstorm activity which developed with little warning over the Southern Appalachian Mountains. Beginning generally on the morning of August 29, the rainfall was practically over 24 hours later. Rainfall amounts exceeded 10 inches in some parts of the French Broad River basin as shown on Plate 5. In contrast to the July 1916 storm, the late August storm was heavy over the area

PLATE 4



~10~ INCHES RAINFALL

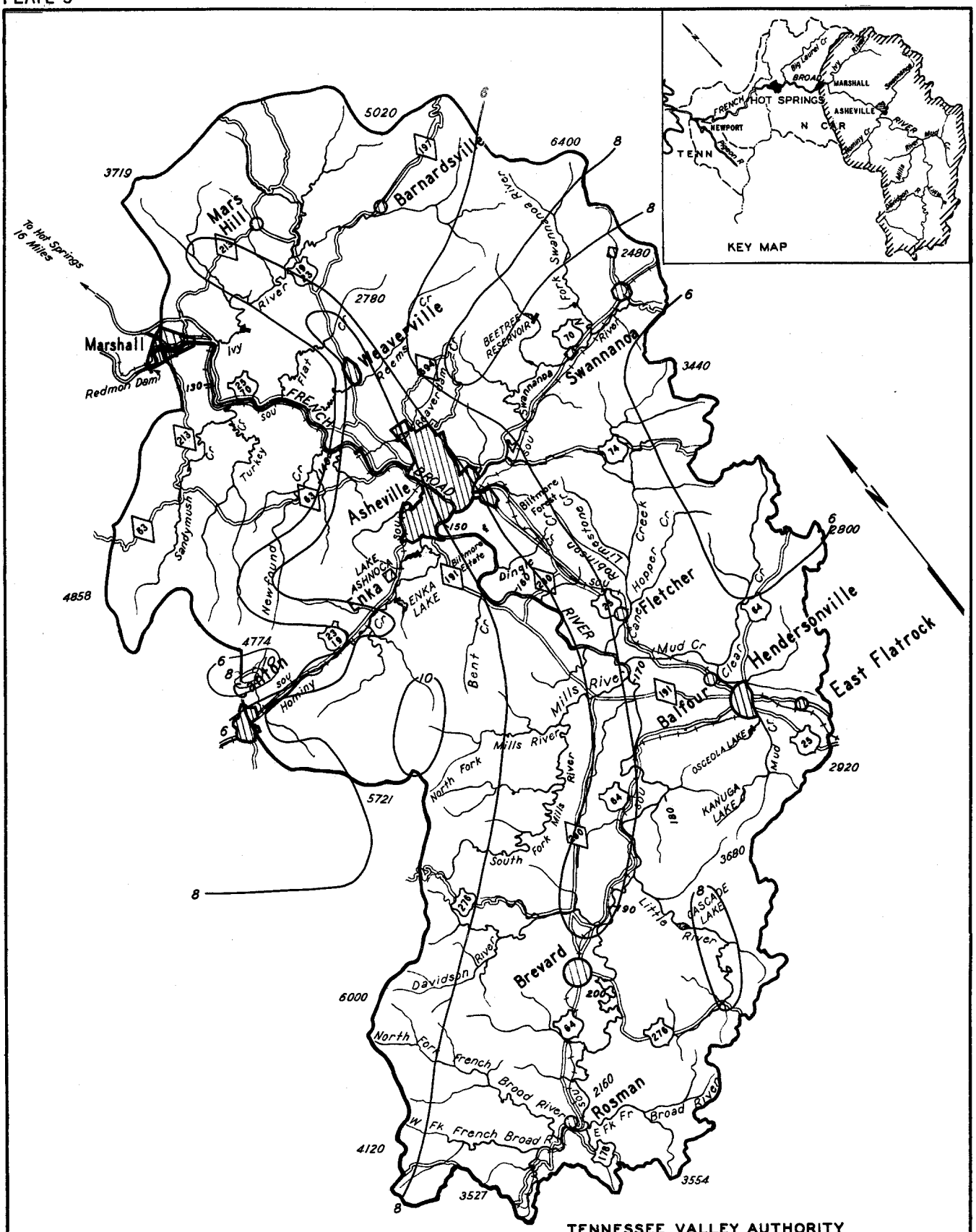
Scale 0 5 10 Miles

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

UPPER FRENCH BROAD AREA SHOWING JULY 1916 ESTIMATED STORM RAINFALL

JULY 1960

PLATE 5



TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

UPPER FRENCH BROAD AREA SHOWING LATE AUGUST 1940 STORM RAINFALL

JULY 1960

~10~ INCHES RAINFALL

Scale 0 5 10 Miles

below Asheville. Five to eight inches of rain fell in this region, causing large floods on the tributary streams. As a result of this inflow, the peak discharge at Hot Springs was increased nearly 120 percent over that at Asheville with an increase in drainage area of only 65 percent. The crest stage at Hot Springs occurred at 8 a. m. on August 30, four hours earlier than the crest at Asheville.

The 1940 flood on the river at Hot Springs was 4 to 6 feet lower than that of July 1916 and caused no serious damage in the town. There was some loss to crops in the bottoms. Figure 3 shows two views of the flood at Hot Springs.

April 5, 1957

Since 1940 there have been several moderate floods on the river at Hot Springs. The largest of these occurred on April 5, 1957, following a 24-hour rainfall averaging about 4 inches over the French Broad River watershed. The crest stage at Hot Springs was 19. 25 feet at the Weather Bureau gage on the new highway bridge. This stage is about 5 feet lower than the August 30, 1940, flood, and only minor overflow occurred.

Spring Creek

Of the many rises that have occurred on Spring Creek at Hot Springs, there were only a few high enough for local residents to consider them as outstanding. These were described as follows.

April 1896

This flood is recalled principally in the upper reaches of Spring Creek some 10 miles or more south of Hot Springs. Mrs. H. S. Davis remembered that the flood occurred in April 1896, the year after she was married. Her husband had a sawmill run by water power just above Spring Creek School and the high water carried away a great number of logs. Mr. O. P. Martin, a resident of the area for 82 years, lived in Hot Springs from 1888 to 1896. He remembered the flood and said that it washed out a dam on the creek. Neither Mrs. Davis nor Mr. Martin could show the height reached by the flood but both considered it to be outstanding.

August 30, 1940

Rainfall in the Spring Creek watershed on August 29-30, 1940, ranged from 4.5 to 6.5 inches with the heavier amounts in the headwater region. The rise occurred during the night.

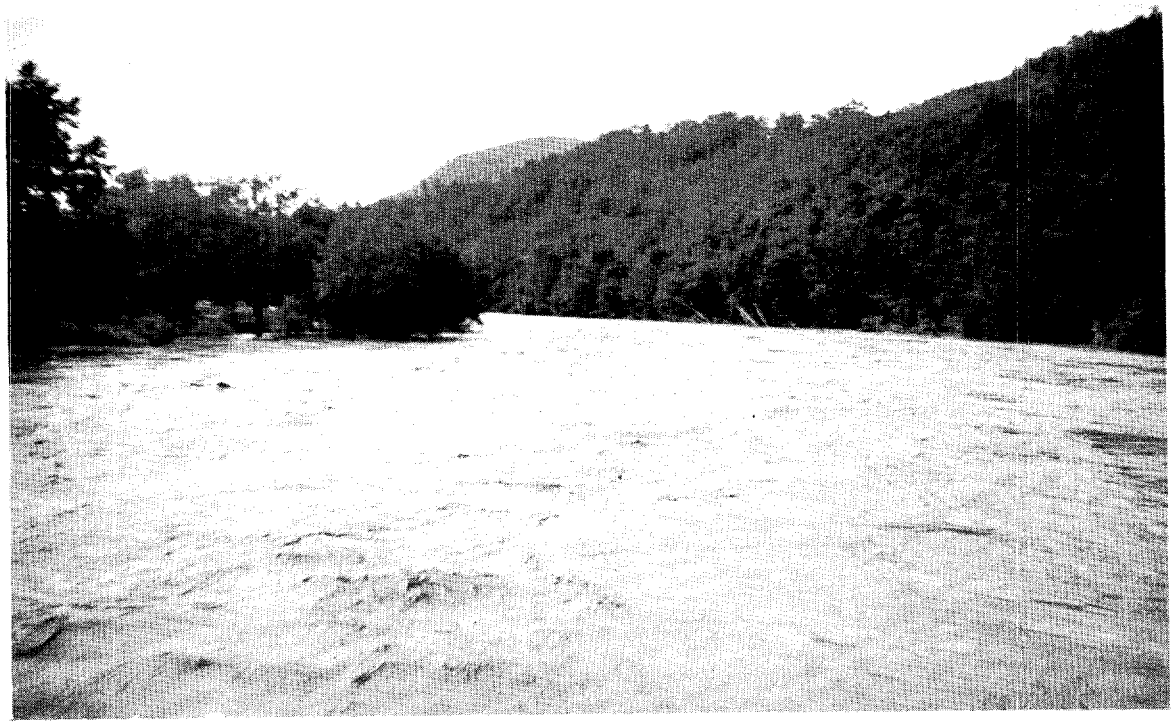
Troy C. Harrison, 60 years old and a resident on Spring Creek all his life, considered the 1940 flood to be the highest in his memory on the creek in Hot Springs. He could not recall any flood prior to 1940 that was of any consequence.

High water marks obtained by the Geological Survey immediately after the flood at Mile 1.3 and another mark shown by Mrs. Tweed at Andrew Avenue, Mile 0.26, indicated that the 1940 flood was very nearly the same height as a flood in June 1949. Only minor overflow occurred in Hot Springs as a result of the headwater flood on the creek.

June 16, 1949

Floods occurred throughout the French Broad River basin on June 16 and 17, 1949, as a result of a series of showers that began on June 11. During the first four days rainfall totaling 1 to 3 inches fell in the Spring Creek watershed. In the evening of June 15 heavy rain began and continued for 20 to 22 hours. Total rainfall for this part of the storm in the Spring Creek watershed ranged from 3.0 to 5.5 inches.

A number of people in the Hot Springs vicinity said the flood on June 16, 1949, was the largest they had ever seen on Spring Creek. However, high water marks for this and the August 30, 1940, flood showed little difference between these two rises in Hot Springs. There is no indication that the 1949 flood caused any significant damage along the creek.



Upstream from U. S. Highway 70 bridge

Downstream from U. S. Highway 70 bridge

Figure 3.--FRENCH BROAD RIVER AT HOT SPRINGS, AUGUST 30, 1940

III.

REGIONAL FLOODS

Tennessee Valley Authority
Division of Water Control Planning
Hydraulic Data Branch

III.

REGIONAL FLOODS

Large floods have been experienced in the past on streams in the general geographical and physiographical region of Hot Springs, North Carolina. Heavy storms comparable to those that caused these floods could occur over the French Broad River and Spring Creek watersheds. In this event, floods would result on these streams comparable in magnitude to those that have occurred on the neighboring streams. Floods of this size are designated as Regional Floods. It is therefore desirable in connection with any determination of future floods that may occur on the French Broad River and Spring Creek to consider floods that have occurred on streams in the Hot Springs region on watersheds whose topography, watershed cover, and physical characteristics are similar to the watersheds of these two streams.

Maximum Known Regional Floods

Table 7 lists the maximum known floods experienced on watersheds comparable to those of the French Broad River and Spring Creek. The region considered includes watersheds generally within 100 miles of Hot Springs, although those watersheds comparable to the Spring Creek watershed are within 50 miles of Hot Springs. Only watersheds in the Appalachian Mountain region are included since those that lie to the west and northwest with headwaters in the Great Valley differ significantly in watershed characteristics from the French Broad River and Spring Creek watersheds.

In considering floods on watersheds comparable to that of Spring Creek, all floods resulting from hurricane-type storms passing near the southern and eastern boundary of the Tennessee River Basin were excluded. The Spring Creek watershed is shielded to a great extent from this type of storm by the Basin Divide and thus does not experience the very heavy and intense rains that occur during hurricane storms on the headwaters of streams rising on the Divide.

TABLE 7

MAXIMUM KNOWN REGIONAL FLOODS

FRENCH BROAD RIVER AT HOT SPRINGS, NORTH CAROLINA

Map Reference No.	Stream	Location	Drainage Area	Date	Peak Discharge	
					Amount	Per Sq. Mi.
			sq. mi.		cfs	cfs
1	S. Fk. Holston River	at Kingsport, Tenn.	1935	May 22, 1901	110,000	57
2	Little Tennessee River	at Calderwood, Tenn.	1862	March 1867	150,000	81
3	French Broad River	nr Newport, Tenn.	1858	March 1867	110,000	59
				February 28, 1902	101,000	54
				July 16, 1916	97,000	52
4	Nolichucky River	nr Morristown, Tenn.	1679	May 1901	85,000	51
5	French Broad River	at Hot Springs, N. C.	1563	July 16, 1916	110,000*	70
6	Broad River	nr Gaffney, S. C.	1490	August 14, 1940	119,000	80
7	French Broad River	at Marshall, N. C.	1332	July 16, 1916	115,000	86
8	Hiwassee River	nr Reliance, Tenn.	1223	September 1898	90,000	74
9	Nolichucky River	nr Greeneville, Tenn.	1141	May 22, 1901	110,000	96
10	French Broad River	at Asheville, N. C.	945	July 16, 1916	110,000	116
11	Broad River	nr Boiling Springs, N. C.	864	August 16, 1928	73,300	85
12	Nolichucky River	at Embreeville, Tenn.	805	May 22, 1901	120,000	149
13	Ivy River	nr Marshall, N. C.	158	June 1876	14,000	89
14	Pigeon River	at Canton, N. C.	133	August 30, 1940	31,600	238
15	Big Laurel Creek	nr Stackhouse, N. C.	126	January 31, 1957	7,700	61
16	E. Fk. Tuckasegee River	nr Tuckasegee, N. C.	80.3	August 30, 1940	30,000	374
17	Sandymush Creek	nr Alexander, N. C.	79.5	August 30, 1940	20,000	252
18	Spring Creek	at Hot Springs, N. C.	71.5	August 30, 1940	6,300	88
19	Caney Fork	ab Cowarts, N. C.	39.4	August 30, 1940	21,700	551
20	Newfound Creek	nr Leicester, N. C.	34.2	August 30, 1940	12,000	351
21	W. Fk. Pigeon River	nr Waynesville, N. C.	12.2	August 30, 1940	16,500	1,350
22	Middle Prong, W. Fk. Pigeon River	ab Spruce, N. C.	8.4	August 30, 1940	16,400	1,950

*Discharge revised.

The storm of March 1867 is one of the earliest great storms known to have occurred in this region. The floods that resulted from this storm are among the largest of record over a considerable portion of the eastern Tennessee Valley. The storm produced the highest flood of record on the lower French Broad, Holston, and Little Tennessee Rivers as well as on the upper half of the Tennessee River. Rainfall in the order of 12 to 14 inches is estimated to have fallen in a period of several days over the Little Tennessee River Basin while the French Broad River Basin experienced an estimated 8 to 9 inches.

The storm of May 18-21, 1901, is a notable example of another early, although well documented, large storm that occurred in the region. This storm extended from the eastern Tennessee River Basin east as far as the coast. Rainfall was particularly heavy in the vicinity of the Watauga and Nolichucky Rivers where approximately 8 inches of rain fell in a 24-hour period on ground that was saturated from earlier rains. The numerous "waterspouts" and landslides that were reported in the area attest to the intensity of the rainfall. A devastating flood that resulted on the Nolichucky River became known as the "May Tide."

Tropical hurricanes have resulted in many problem floods in this region. The hurricane of July 1916 and that of mid-August 1940, which occurred within a span of 24 years, caused record high floods on numerous watersheds in the French Broad River Basin as well as other watersheds in the region. The first of these, that of July 15-16, 1916, was actually the second of two hurricanes that moved inland during July 1916. The first hurricane, although it dissipated over southern Alabama, brought sufficient rainfall to western North Carolina to saturate the ground. The hurricane that followed on July 15-16 brought a deluge of rain to the mountains of North Carolina, with a recorded maximum of 22.2 inches in a 24-hour period at Altapass, about 45 miles east of Hot Springs. Particularly devastating floods resulted on the upper French Broad River and headwater tributaries in the Blue Ridge Mountains. Rainfall diminished rapidly west of the Blue Ridge Mountains and the floods decreased in magnitude. At Newport, Tennessee, the 1916 flood discharge was exceeded by the floods of March 1867 and February 1902.

The hurricane of mid-August 1940 produced large floods on watersheds along the Blue Ridge Mountains from the Watauga River as far south as

the Hiwassee Basin. During the period August 11 to 14, rainfall totaled 13 to 15 inches at several locations along the Blue Ridge Mountains. Unusually high floods were experienced on the upper Nolichucky and Broad Rivers.

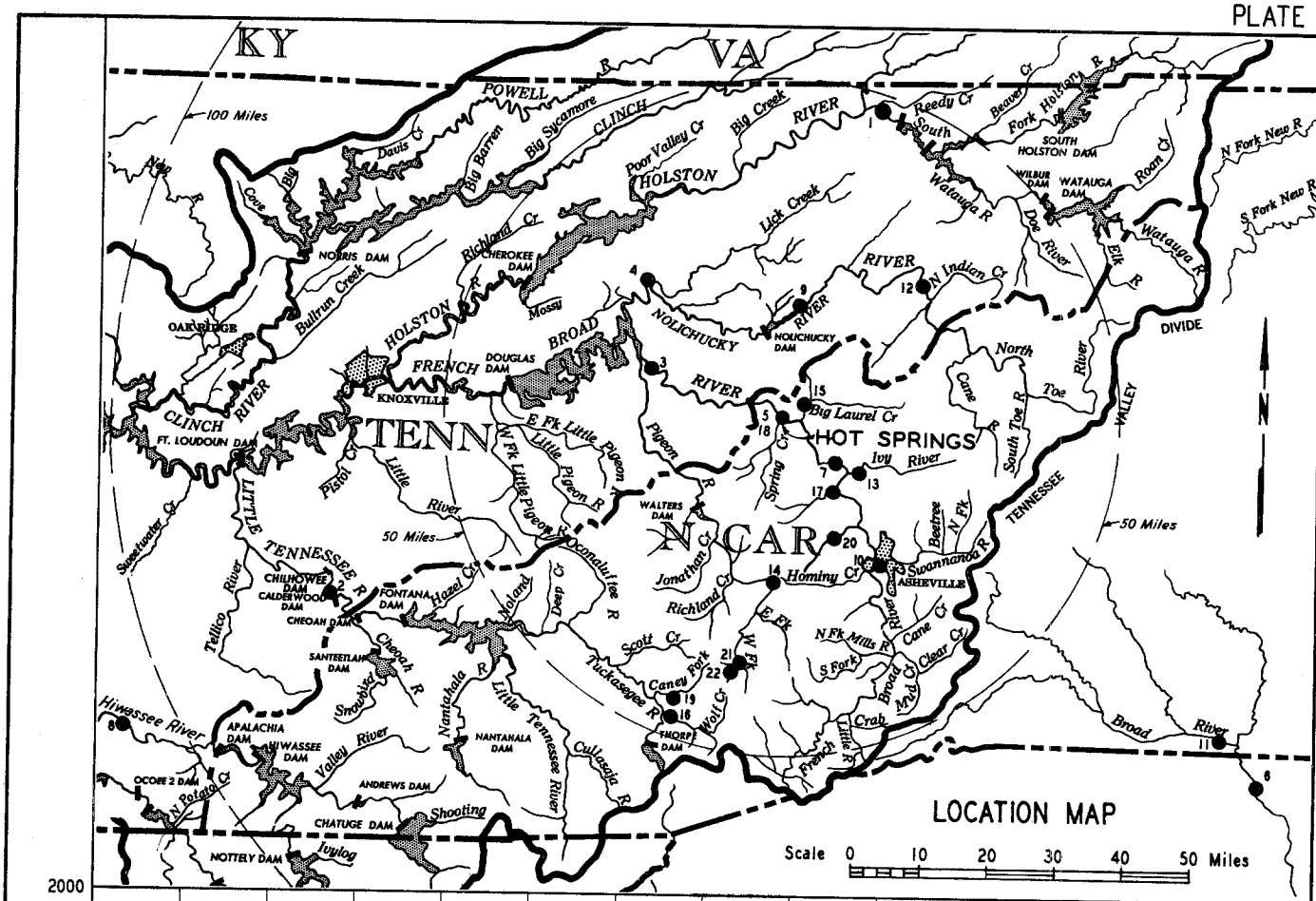
A second storm that occurred in August 1940 again brought heavy rain to the western North Carolina area. The thunderstorms of August 29-30, 1940, brought rainfall amounts up to 13 inches in a relatively narrow band along the Blue Ridge Mountains. The upper Tuckasegee River, which had been only moderately flooded by the mid-August storm, rose to record heights during this latter storm when 10 inches of rain fell in approximately 24 hours.

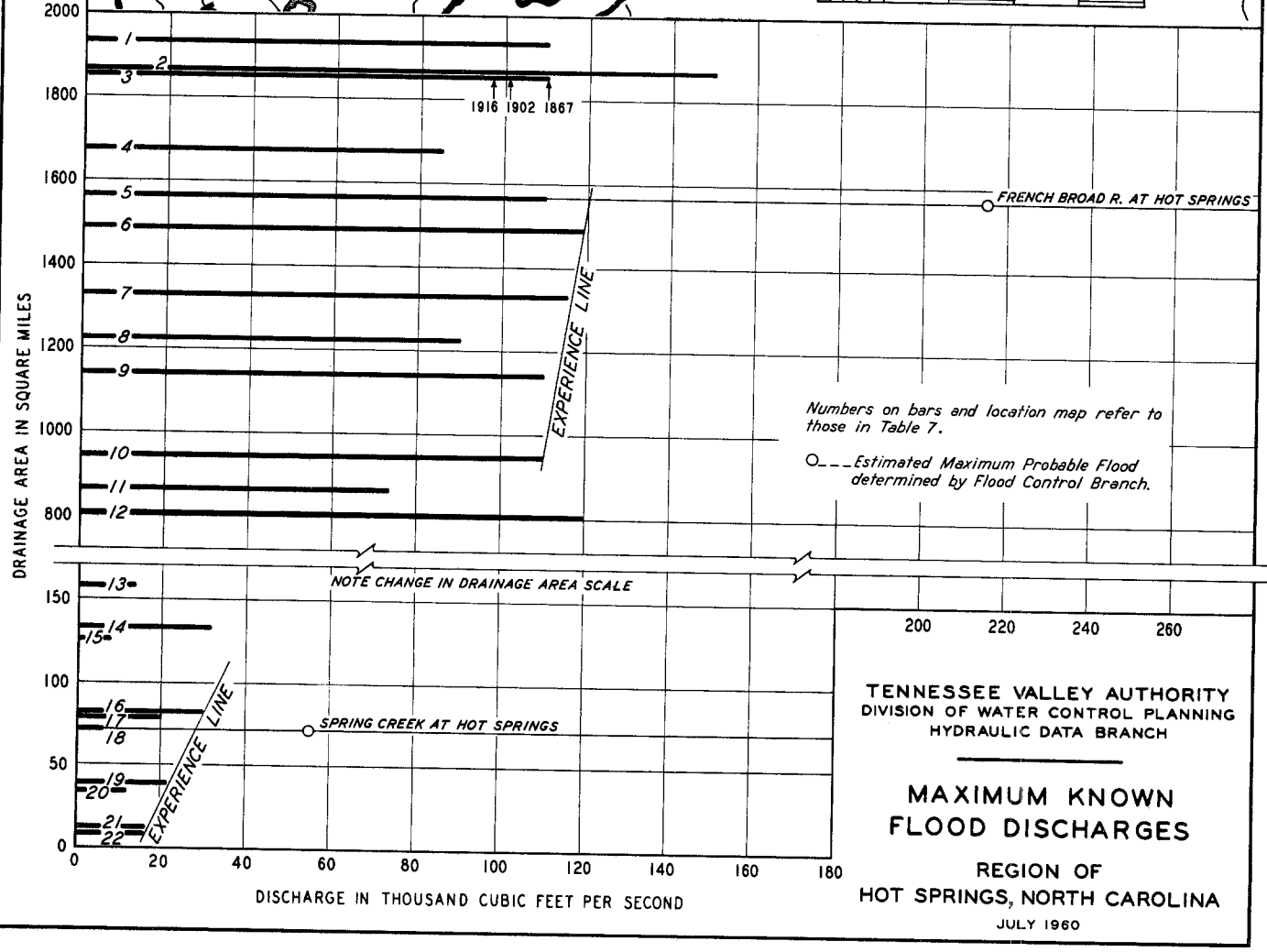
All of the floods listed in Table 7 have occurred on watersheds in the Hot Springs region whose physical characteristics are generally similar to those of the French Broad River and Spring Creek. This indicates that floods of like magnitude, modified to take into account differences in drainage area characteristics, could occur on the French Broad River and Spring Creek. However, the effect of an important characteristic of the French Broad River in modifying flood discharges must be taken into account. As has been described in Section II of this report, there is a broad flood plain and unusually flat slope in the 70-mile reach of the river between Rosman and Asheville. The substantial natural storage of flood waters that occurs in this reach has a significant effect on both timing and crest discharge of floods at Hot Springs.

French Broad River and Spring Creek vs. Regional Flood Discharges

Plate 6 is a diagram of the flood discharges listed in Table 7. Included on the plate is a map showing the locations of the discharge measurements.

Plate 6 shows that two known floods in the region, that on the Little Tennessee River in 1867 and that on the Nolichucky River in 1901, have materially exceeded the 1916 flood on the French Broad River. A regional flood at Hot Springs based on experienced floods on these two watersheds would be about 140,000 cubic feet per second. However, although the watersheds of the Little Tennessee River and the Nolichucky River are generally comparable to that of the French Broad River above Hot Springs, there is a significant difference in the valleys of these streams. The broad flood plain and flat slopes in the French Broad River valley above Asheville act to reduce flood peaks on the river below Asheville.





TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

MAXIMUM KNOWN FLOOD DISCHARGES

REGION OF HOT SPRINGS, NORTH CAROLINA

JULY 1960

ASF-1311

A regional flood, then, on the French Broad River below Asheville would be less than a similar flood on either the Little Tennessee or Nolichucky Rivers where no unusual storage capacity exists.

If the Little Tennessee River and Nolichucky River are excepted, a regional flood at Hot Springs in the order of 120,000 cubic feet per second might be expected. This flood would be based on the mid-August flood experienced on the Broad River and the 1916 flood on the French Broad River at locations upstream from Hot Springs. This Regional Flood at Hot Springs is 10,000 cubic feet per second more than the peak discharge for the 1916 flood, which had begun to decrease in magnitude, but at the same time it, in effect, gives credit to the natural storage above Asheville for a reduction of 20,000 cubic feet per second from what the peak would have been had this storage not existed.

Considering only the floods that have been experienced in the region of Hot Springs it would be reasonable to expect future floods on the French Broad River and Spring Creek to be in the order of those shown in Table 8. Floods of these magnitudes are designated as Regional Floods.

TABLE 8

REGIONAL FLOOD DISCHARGES

Stream	Location	Drainage Area sq. mi.	Peak Discharge cfs
French Broad River	U. S. Highways 25 and 70	1565	120,000
Spring Creek	Bridge Street	71.9	28,000

The profiles of the Regional Floods on the French Broad River and Spring Creek are shown on Plate 9.

IV.

MAXIMUM PROBABLE FLOODS

Tennessee Valley Authority
Division of Water Control Planning
Flood Control Branch

IV.

MAXIMUM PROBABLE FLOODS

The preceding sections have told about the floods that have already occurred and about the Regional Floods on the French Broad River and Spring Creek at Hot Springs, North Carolina. This section discusses the Maximum Probable Floods that may reasonably be expected. Floods of these magnitudes are the kind considered in planning the construction and operation of protective works, the failure of which might be disastrous.

The French Broad River drains 1,663 square miles at the lower limit of the present study, including the 72-square-mile Spring Creek area. Extreme floods on both the French Broad River and Spring Creek may result from either of two types of storms--intense periods of rainfall during winter storms of fairly long duration or short-duration storms of the cloudburst or hurricane type usually occurring in the summer. Infiltration and other losses are generally low in winter and generally high in summer.

DETERMINATION OF MAXIMUM PROBABLE FLOODS

In determining the Maximum Probable Floods on the French Broad River and Spring Creek, consideration was given to great storms and floods that have already occurred on these watersheds and to those which have occurred elsewhere but could have occurred on these areas. This procedure provides information about possible flood and storm occurrences additional to that which can be gained from the short-term local hydrologic records alone.

The maximum known flood on the French Broad River in the vicinity of Hot Springs occurred in July 1916 with a discharge of about 110,000 cubic feet per second. On Spring Creek the maximum known floods are those of June 1949 and August 1940, both of which had peak discharges of about 6,300 cubic feet per second. It is reasonable to expect that greater floods than those of the known past will occur on both streams.

Observed Storms

Observed storms are meteorologically transposable to the French Broad River and Spring Creek watersheds from within a broad region extending generally from the Atlantic Ocean to the Appalachian Divide and from Florida through Pennsylvania. The moisture source for storms in this region is the warm, moist air flowing northward from the tropical Atlantic Ocean. In general, the moisture potential for a given region decreases with its distance from the moisture source. When transferring storms within the broad region to the French Broad River area, appropriate adjustments were made for differences in this moisture potential. The mountains surrounding this area have a marked influence on the storm patterns, and allowance also was made for this influence.

Table 9 lists known rainfall depths for several large storms transposable to the French Broad area.

TABLE 9

SELECTED MAXIMUM OBSERVED STORMS

Date	Location	6-Hour Rainfall Depth, Inches	
		72 Sq. Mi.	1,663 Sq. Mi.
July 1916	North Carolina	7.6	5.3
August 1939	New Jersey	9.3	6.2
September 1940	New Jersey	17.9	7.0
October 1941	Florida	10.9	6.1

On the basis of these and other data, as adjusted for conditions in the watersheds, a rainstorm of 10.4 inches in 6 hours was adopted for computing the French Broad River Maximum Probable Flood and 12.9 inches in 6 hours for the Spring Creek Maximum Probable Flood.

Storms greater than these can occur. Storms considered to be the greatest from a meteorological standpoint would be approximately 1.7 times that adopted for both the French Broad River and Spring Creek Maximum Probable Floods.

Observed Floods

Factors such as the meteorology of the region and flood-producing characteristics of the watershed were given consideration in determining whether peak discharges on other streams are applicable to the French Broad River and Spring Creek. In addition to the floods listed in Table 7 of Section III, Table 10 lists peak discharges for observed floods on several streams of approximately the size of the French Broad River and Spring Creek. For comparison, the discharge of the highest flood on each stream at Hot Springs is listed.

TABLE 10

SELECTED MAXIMUM OBSERVED FLOODS

IN VICINITY OF HOT SPRINGS, NORTH CAROLINA

Stream	Location	Drainage Area sq. mi.	Date	Peak Discharge Amount cfs	Peak Discharge Per Sq. Mi. cfs
N. F. Catawba R.	Woodlawn, N. C.	41.8	1940	55,000	1,320
Elk Creek	Elkville, N. C.	50	1940	70,000	1,400
Watauga R.	Sugar Grove, N. C.	55.1	1940	41,000	745
S. Toe R.	Newdale, N. C.	60.8	1927	33,000	544
Linville R.	Branch, N. C.	65	1940	39,500	608
Wilson Creek	Adako, N. C.	66	1940	99,000	1,500
Warrior Fork	Morganton, N. C.	80.5	1940	38,000	470
Watauga R.	Sugar Grove, N. C.	90.8	1940	50,800	560
Yadkin R.	Wilkesboro, N. C.	493	1940	160,000	325
French Broad R.	Bent Creek, N. C.	676	1916	105,000	155
James R.	Lick Run, Va.	1,369	1877	120,000	88
S. Br. Potomac R.	Springfield, W. Va.	1,471	1877	140,000	95
Catawba R.	Catawba, N. C.	1,535	1940	177,000	115
L. Tennessee R.	Fontana Dam, N. C.	1,571	1867	129,000	82
French Broad R.	Hot Springs, N. C.	1,563	1916	110,000*	70
Spring Creek	Hot Springs, N. C.	71.5	1940 1949	6,300	88

*Discharge revised.

Maximum Probable Flood Discharges

From consideration of the flood discharges in Tables 7 and 10 and of the transposition to the French Broad River and Spring Creek areas of outstanding storms, the peak discharge of the French Broad River Maximum Probable Flood was determined to be 215,000 cubic feet per second throughout the study reach and the Spring Creek Maximum Probable Flood 55,000 cubic feet per second at Bridge Street.

These flood rates were computed from the adopted storms using the unit hydrograph technique. The peak rate for the French Broad River is approximately twice the greatest known flood and for Spring Creek about nine times the greatest known.

The Maximum Probable Floods at Hot Springs can result from two types of storm situations. In one, the situation presented in this report, the storm covers the entire area with the center being located above Asheville, North Carolina. In the other situation, the storm centers over the watershed between Hot Springs and Asheville. The magnitude of the flood crest is essentially the same for either assumption.

Frequency

The frequency of a flood of the magnitude of the Maximum Probable is not susceptible of definite determination. Such a flood would occur on the average only at rather long intervals of time, but it could occur in any year.

Possible Larger Floods

Floods larger than any of those discussed are hydrologically possible. However, the combination of factors that would be necessary to produce such floods would occur at rare intervals. The consideration of floods of this magnitude is of greater importance in some problems than in others and should not be overlooked in the study of any problem. Such floods, because of their extreme rarity and uncertainty of occurrence on a given watershed, need be given greatest consideration where dependence is placed on protective works, the failure of which would cause loss of life or destruction of valuable property.

FLOOD HEIGHTS AND VELOCITIES

Flood Crest Profiles and Overflow Areas

The crest profiles computed for the Maximum Probable Floods on the French Broad River and Spring Creek in the vicinity of Hot Springs are shown on Plate 9. These profiles were computed using stream characteristics for selected reaches as determined from observed flood profiles, topographic maps, and valley cross sections. The cross sections were surveyed in 1960. The overflow areas that would be covered by the Maximum Probable Floods are shown on Plate 7.

The French Broad River Maximum Probable Flood profile is from 8 to 12 feet above elevations experienced in the 1916 flood. The greatest difference occurs just above the bridge at Mile 108. 9. The Maximum Probable Flood profile on Plate 9 is for present-day conditions.

The Spring Creek Maximum Probable Flood profile is from 18 to 21 feet above the 1949 flood.

It is impossible to foretell the destructive effect of velocities (see Velocities and Rates of Rise) on bridges over the streams and structures bordering the streams. In computing the profile of the Maximum Probable Flood there was no choice but to assume the survival of all such structures.

The elevations shown on Plate 9 and the overflow area shown on Plate 7 have been determined as accurately as possible consistent with the basic data, but actual elevations may vary from those shown on the maps. To determine elevations and flooded area limits more accurately would require costly surveys.

Velocities and Rates of Rise

During the Maximum Probable Flood, velocities in the main channel of the French Broad River would range from about 10 to 29 feet per second, the highest velocity occurring at the constricted section at Mile 107. 5 where the total stream cross section is smaller than at any other place within the limits of the study. In the overflow area, velocities would range from about 1 to 10 feet per second with the highest velocity occurring in the right bank overflow area at Mile 104.

The velocities in the channel of Spring Creek range from 8 to 24 feet per second with the maximum occurring at Mile 0.54 just below Pacific Mills pumphouse. The velocities in the overbank area range from 1 to 14 feet per second with the highest velocity occurring in the street on the left bank.

The Maximum Probable Flood on the French Broad River at Mile 109 would rise about 33 feet above low water to its crest stage in about 12 hours. The maximum rate of rise would be about 5 feet per hour.

The Maximum Probable Flood on Spring Creek would rise about 29 feet above low water in 7 hours. The maximum rate of rise would be 8 feet per hour.

These high velocities and rapid rates of rise in combination with deep flooding would create an extremely hazardous situation, especially on the narrow, highly developed flood plain on which Hot Springs is situated.

V.

ACKNOWLEDGMENTS

Tennessee Valley Authority
Division of Water Control Planning

V.

ACKNOWLEDGMENTS

This report has been prepared by the Division of Water Control Planning under the general direction of Reed A. Elliot, Chief Water Control Planning Engineer.

All of the report except Section IV has been prepared by the Hydraulic Data Branch under the immediate supervision of Albert S. Fry, Chief, Hydraulic Data Branch. The report has been edited by James Smallshaw, Assistant Branch Chief. Investigations for compiling Section II, Flood History, were made under the direction of James W. Beverage, Head of the Field Investigations Section, by District Engineer Myron O. Jensen and Area Engineer Joseph S. Enloe. Studies for development of the Regional Flood, Section III, were made under the direction of Willard M. Snyder, Head of the Hydrology Section, by Roger P. Betson. Paul C. Spath, Head of the Hydraulic Investigations Section, and Thomas C. Bounds, Head of the Office Engineering Unit, prepared charts and maps for the report and, together with Mr. Smallshaw and Mr. Enloe, analyzed the flood information. The entire report was typed for reproduction by Margaret S. Ross under the direction of Elizabeth G. Breeden, Head, Administrative Unit. The report cover and photographs in the report were prepared for reproduction by Robert Forbes of the Engineering Administration Section.

Section IV, Maximum Probable Floods, was prepared by the Flood Control Branch under the immediate direction of Edward J. Rutter, Chief, Flood Control Branch. Basic hydraulic data were furnished by the Hydraulic Data Branch. Flood studies were under the supervision of B. J. Buehler, Head, Operation Studies Section. The flood discharges were determined by Donald W. Newton, and the profiles were computed by Logan A. Gillett and Bevan W. Brown, Jr.

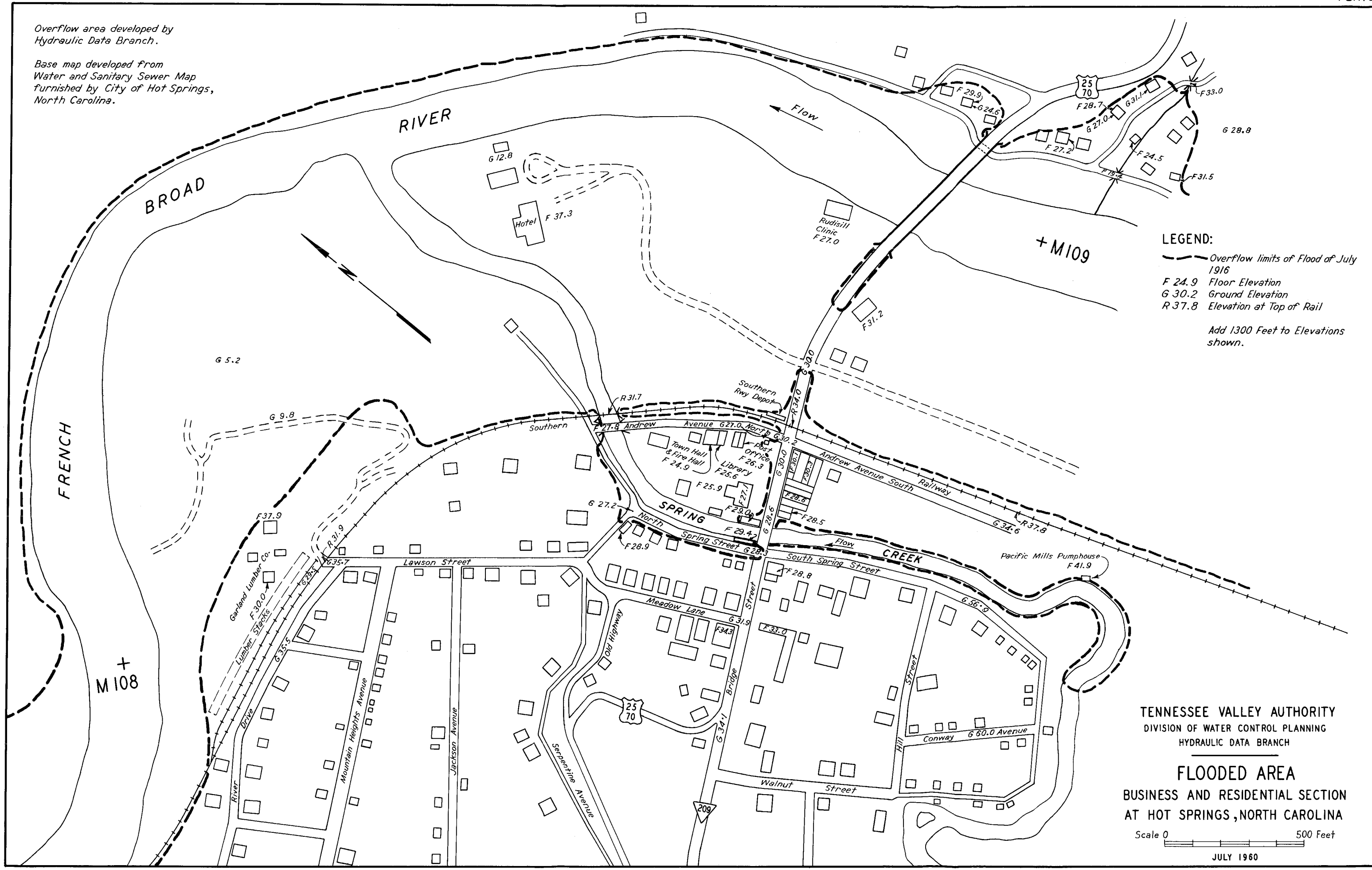
Photographs showing the height of the Maximum Probable Flood were taken by Mr. Smallshaw. The cover picture is from an aerial photograph taken for the Soil Conservation Service.


TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH
FLOODED AREAS
FRENCH BROAD RIVER
AND SPRING CREEK
VICINITY OF HOT SPRINGS, N.C.
Scale 0 1000 2000 3000 Feet
JULY 1960
LEGEND:
July 16, 1916 Flood
Maximum Probable Flood
+M 109 Miles above mouth
③ Cross Section
Contour interval 40 feet
1309.8 Ground elevation
Overflow areas developed by Hydraulic Data Branch. Elevations for Maximum Probable Flood computed by Flood Control Branch.
Base map is a reproduction of a portion of USGS-TVA topographic map 182-NE 1940 edition. Culture as of that date, except for relocation of US 25-70 bridge and some other new structures.
FRENCH
BROAD
HOT SPRINGS
Huff Island
Bartley Island
Paint Rock
Brushy Mtn
Shaleville
Bubbling Spring
Fairview Ch
Shut-in Creek
Mine Hollow
DIXIE HIGHWAY
SOUTHERN
Flow
CLICK CEM
ODD FELLOWS CEM
Pacific Mills
Pumping Station
Lumber Piles
Stream Gage (1952)
Stream Gage (1934-1949)
Corporate Limits
LR 333
RESERVOIR
Trent Branch
Spring Creek
DEEP WATER BRIDGE
M103
M104
M105
M106
M107
M108
M109
M111

ASF-1311

Overflow area developed by Hydraulic Data Branch.

Base map developed from Water and Sanitary Sewer Map furnished by City of Hot Springs, North Carolina.



LEGEND:

- Overflow limits of Flood of July 1916
- F 24.9 Floor Elevation
- G 30.2 Ground Elevation
- R 37.8 Elevation at Top of Rail

Add 1300 Feet to Elevations shown.

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

FLOODED AREA

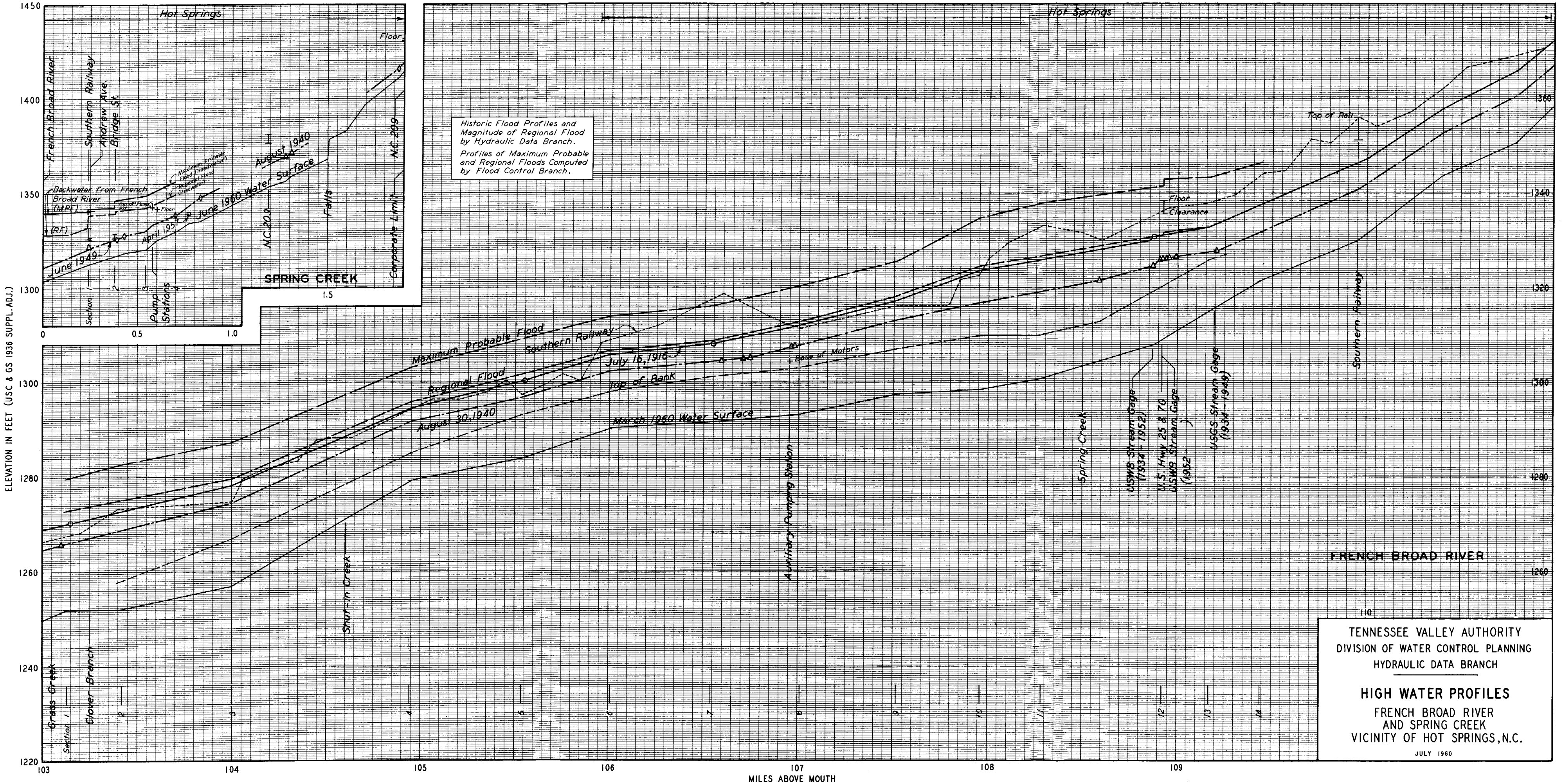
BUSINESS AND RESIDENTIAL SECTION AT HOT SPRINGS, NORTH CAROLINA

Scale 0 — 500 Feet

JULY 1960

ASF-1311

PLATE 9



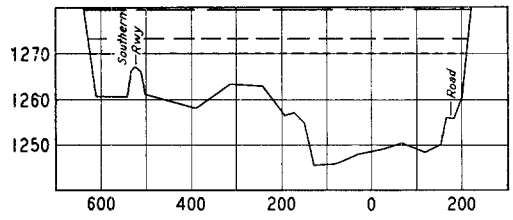
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

HIGH WATER PROFILES

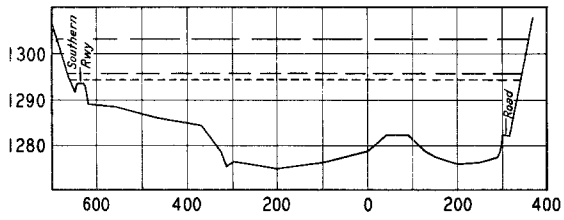
FRENCH BROAD RIVER
AND SPRING CREEK
VICINITY OF HOT SPRINGS, N.C.

JULY 1960

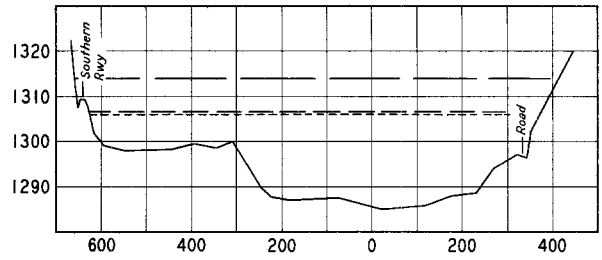
ASF - 1311



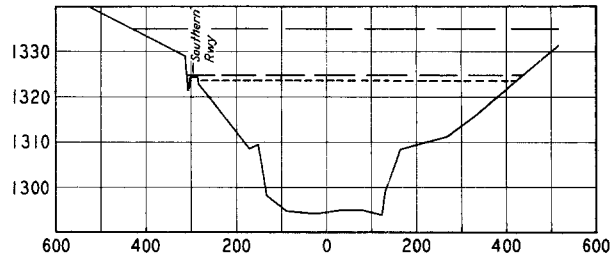
SECTION 1 - MILE 103.13



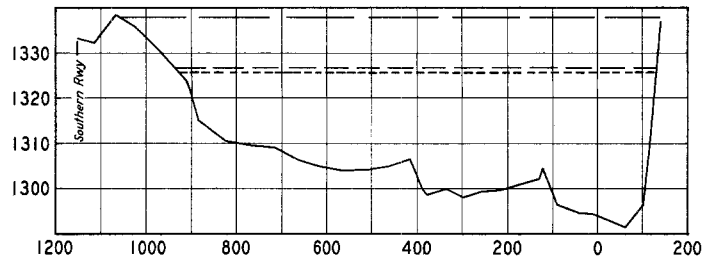
SECTION 4 - MILE 104.94



SECTION 6 - MILE 106.01



SECTION 10 - MILE 107.96



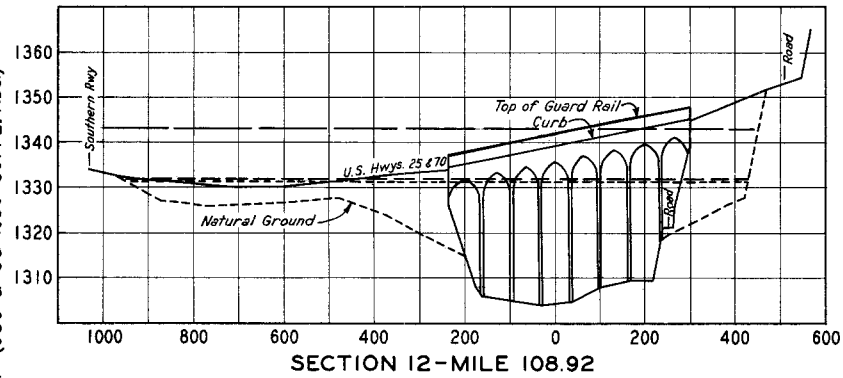
SECTION 11 - MILE 108.28

Section taken looking downstream.

10 Sections not shown.

Elevations of Maximum Probable and Regional Floods computed by Flood Control Branch.

Sections and Elevations of Historic Floods by Hydraulic Data Branch.



SECTION 12 - MILE 108.92

LEGEND:

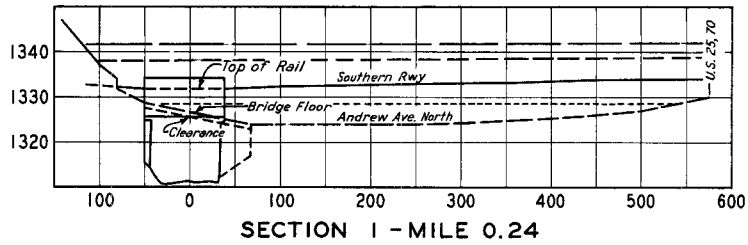
——— Maximum Probable Flood.

— — — Regional Flood.

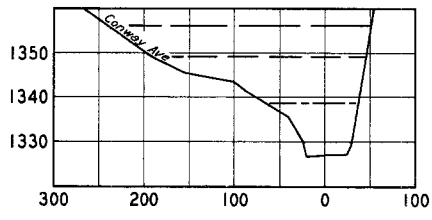
- - - - - - - Flood of July 16, 1916.

——·——·—— Flood of June 16, 1949 on Spring Creek.

FRENCH BROAD RIVER



SECTION 1 - MILE 0.24



SECTION 4 - MILE 0.70

HORIZONTAL DISTANCE IN FEET

SPRING CREEK

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

VALLEY CROSS SECTIONS

FRENCH BROAD RIVER
AND SPRING CREEK
VICINITY OF HOT SPRINGS, N. C.

JULY 1960

ASF-1311