

TENNESSEE VALLEY AUTHORITY
KNOXVILLE, TENNESSEE

June 29, 1959

Mr. Harold V. Miller, Executive Director
Tennessee State Planning Commission
Room C-106, Cordell Hull Building
Nashville 3, Tennessee

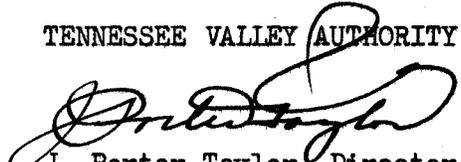
Dear Mr. Miller:

In response to the request of the Johnson City Regional Planning Commission and the Tennessee State Planning Commission, TVA has prepared the report Floods on Brush Creek, Vicinity of Johnson City, Tennessee. 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 Johnson City. 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 BRUSH CREEK
IN VICINITY OF
JOHNSON CITY TENNESSEE

REPORT NO. 0-5868

KNOXVILLE TENNESSEE
JUNE 1959

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COVER PHOTO

This is Fountain Square in Johnson City early on the morning of August 9, 1938.
(Photo by Burr Harrison Studio, Johnson City)

PREFACE

Tennessee Valley Authority
Division of Water Control Planning

PREFACE

This is a report of the flood situation along Brush Creek in the vicinity of Johnson City, Tennessee, and covers the creek from the Embreeville Junction area, through Johnson City to the mouth in Watauga River.

This is one of a series of reports that TVA is preparing to aid communities in the Tennessee Valley (1) in the solution of local flood problems which are not eliminated by TVA's reservoir system and (2) in the best utilization of lands subject to overflow. These reports are based on work that 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. These data provide the basis for preparation of flood histories of many streams which information may then be made available to states, communities, and groups which are interested in local flood problems. This report has been prepared at the request of the Johnson City Planning Commission through the Tennessee State Planning Commission.

From Embreeville Junction through Johnson City, Brush Creek follows a winding, rather steeply sloping course for about 5 miles. The flood plain of the Creek through this reach varies in width up to about 1000 feet and most of the flood plain is highly developed. The upper part of the reach has one large mill and residential areas in the flood plain. The flood plain through Johnson City is built up with commercial establishments. Downstream from Johnson City the creek extends for 3-3/4 miles through a narrow flood plain to the mouth in Watauga River. This part of the flood plain is used chiefly for agriculture and offers scant possibilities for development.

Overbank flooding along Brush Creek occurs as a result of intense rainfall on the watershed above and in Johnson City. The banks of Brush Creek are generally low and overflow occurs at stages 3 to 6 feet above stream bed.

Information concerning floods on Brush Creek is sparse, but what is known of such floods indicates that the largest flood was on May 29, 1908. At that time, the creek reached the highest stage in the memory of the oldest inhabitants. This flood overflowed the sections of the business district of Johnson City that lie in the flood plain of the creek and considerable damage resulted. At that time there were bridges across the creek and buildings in the flood plain, but these developments were not nearly so extensive as those that now exist. The covered section of the creek had not been constructed. The changes that have taken place in the flood plain are such that if the 1908 flood were to recur today, the height of the flood through Johnson City would be higher than it was in 1908. A flood almost as high as that in 1908 occurred on August 9, 1938. Again the business district was overflowed and considerable damages were suffered.

Other big floods on Brush Creek came in 1912, 1916, 1919, and 1922.

The largest past floods have occurred on Brush Creek during the months from May through September. However, the drainage area of the creek is relatively small and large floods could occur during any month. Brush Creek rises quickly to its highest stages in a few hours. This imposes a certain element of danger to life to the residents in the flood plain, especially if the flood comes at night.

Velocities of the water in the main channel ranged from 7 to 9 feet per second during the August 1938 flood. Overbank velocities were 5 or more feet per second. During floods larger than that of 1938 both channel and overbank velocities would be greater depending on the magnitude of the flood.

This report is in three parts which treat (1) a history of past floods on Brush Creek, (2) the development of a Regional Flood based upon the largest past floods on streams in the general region of Johnson City, and (3) the Maximum Probable Flood that has been estimated as possible of occurrence on Brush Creek at some future time.

The first section of the report brings together a record of the largest known floods on Brush Creek. A profile is presented showing the high water crest for the flood of August 9, 1938. High water marks for other floods are shown where available. Maps show the area that was inundated by the 1938 flood.

The second section of this report treats of the Regional Flood which is derived from consideration of the largest floods known to have occurred on

streams whose watersheds have similar physical characteristics located in the same general geographic region as that of Johnson City and within about 100 miles of this city. Floods in this category, which have been experienced on streams having characteristics similar to and located in the same general region as Johnson City, together with the Maximum Probable Flood described in Section III of this report, indicate the magnitude of floods that may reasonably be expected to occur in the future on Brush Creek at Johnson City. A profile of the Regional Flood on Brush Creek, the magnitude of which is comparable to that on streams in the region of Johnson City, is included in this report.

The third section of the report relates to the Maximum Probable Flood that has been developed for Brush Creek. Floods of this magnitude on most streams are considerably larger than any that have been experienced 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. A profile for this flood on Brush Creek and a map showing the areas which would be inundated by such a flood are included in this report.

In problems concerned with the control of developments in the flood plain of Brush Creek, it is important to give appropriate consideration to the possible future occurrence of floods of the magnitude of those that are recognized as possible on Brush Creek at Johnson City. The facts should be weighed with regard to such floods in reaching decisions as to how large floods to consider in planning for the use and development of the Brush Creek flood plain.

This report does not include plans for the solution of the flood problems of Brush Creek. Rather, it is intended to provide a basis for further study and planning on the part of the city 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 future use made of the flood plains through zoning and subdivision regulations, or (3) a combination of the two approaches.

The information given in this report should be useful in planning new developments in the Brush Creek flood plain. The maps in the report show the extent of the flooded areas and the profile shows elevations of high

water through the reach of the stream covered by this report. Elevations of the ground are shown by contours and by spot elevations on the map. Cross sections also show ground elevations along the line of each section. From these, the depth of probable flooding at any location may be ascertained either in the event of (1) the recurrence of the largest known historic flood, (2) the occurrence of a Regional Flood the magnitude of which is comparable to those already experienced on streams in the vicinity of Johnson City, or (3) the occurrence of the much larger Maximum Probable Flood. Having this information, floor levels for buildings may be planned either high enough to avoid flood damage or at a lower elevation with recognition of the chance and hazards of flooding that are being taken. Probably most large developments would have site maps made by private engineering firms. Such maps would show ground elevations in considerably greater detail than do the maps in this report and, in conjunction with the maps and profile in this report, would provide the necessary basis for the development of any site.

I
PAST FLOODS
ON
BRUSH CREEK

Tennessee Valley Authority
Division of Water Control Planning
Hydraulic Data Branch

I.

PAST FLOODS ON BRUSH CREEK

This section of the report describes investigations of the history of floods that have occurred on Brush Creek in the vicinity of Johnson City, Washington County, Tennessee. The investigations cover 8-3/4 miles of the creek extending from about a mile above the upstream corporate limits of Johnson City to the mouth of the creek in Watauga River.

Brush Creek drains a watershed of about 16 square miles about 9 miles long and 2 miles wide. At the upstream corporate limits of Johnson City, which is located near the center of the watershed, the drainage area is 3.4 square miles. These drainage areas exclude sink hole areas in the watershed mostly above Johnson City.

No records of stream stages or discharges have been maintained on Brush Creek except for one 15-month period in 1932 and 1933 during which no important floods occurred. In the absence of such records, research investigations have been made by Hydraulic Data Branch engineers to obtain information on floods on Brush Creek. A careful search has been made of newspaper files covering the area, and local residents and historians have been interviewed. While the information that has been found is somewhat fragmentary, these investigations have made it possible to develop a useful even though incomplete history of known floods on Brush Creek.

SUMMARY OF FLOOD HISTORY

1. The greatest flood known in the past 85 years along Brush Creek in the Johnson City vicinity occurred May 29, 1908.
2. The second highest known flood occurred August 9, 1938.



Figure 1. --MAY 29, 1908, FLOOD

The upper view shows Brush Creek overflowing its flood plain along Roan Street which crosses the creek on the bridge near the center of the picture. The lower view is south along Boone Street toward Market Street. The building with the columns is the City Hall.

(Photos courtesy of Mr. Oscar A. Campbell, Johnson City)



3. A flood occurred September 4, 1922, which was 2 feet higher than 1938 in the vicinity of Embreeville Junction above Johnson City but was about one foot lower in the business district of Johnson City.

4. A flood of somewhat lesser magnitude than that of September 1922 occurred in August 1919. Other large floods occurred in August 1912 and July 1916.

5. The known large floods of the past on Brush Creek have resulted chiefly from intense local thunderstorms over the relatively small watershed during the late spring and summer months. However, floods could occur in any month of the year.

6. An area approximately 1,000 feet by 1,000 feet in the heart of the Johnson City business district is affected by large floods on the creek. Flooding above and below town causes little damage except in the Embreeville Junction section where a number of houses are located in the flood plain.

7. A length of 3,300 feet of the creek is covered through the central part of the city. The capacity of this is inadequate to carry large floods without overflow. Where buildings are located over the covered creek section, the columns supporting the building floors tend to obstruct the flow of water.

8. Overbank flooding occurs on the open-channel portions of Brush Creek at stages 3 to 6 feet above stream bed.

9. Twenty-nine street and road bridges and fourteen railroad bridges cross Brush Creek in the 8-3/4-mile reach investigated. In general these bridges restrict the waterway so that they constitute obstructions to flood flows and increase the height of floods.

BRUSH CREEK BASIN

Settlement

Settlement of the Johnson City area dates from about 1775, a few years after the first settlers moved into the Boone Creek and Watauga regions. Early grants covering the site of Johnson City were to David Jobe, Jacob Hoss, and Robert Young. Apparently, the Jobe family owned the land along the creek

in what is now the business district of the city. According to historical records, Abraham Jobe related that a heavy mass of red brush grew along the creek that flowed through the Jobe estate and that only if one were on horseback could he see over it. The creek was named for this brush.

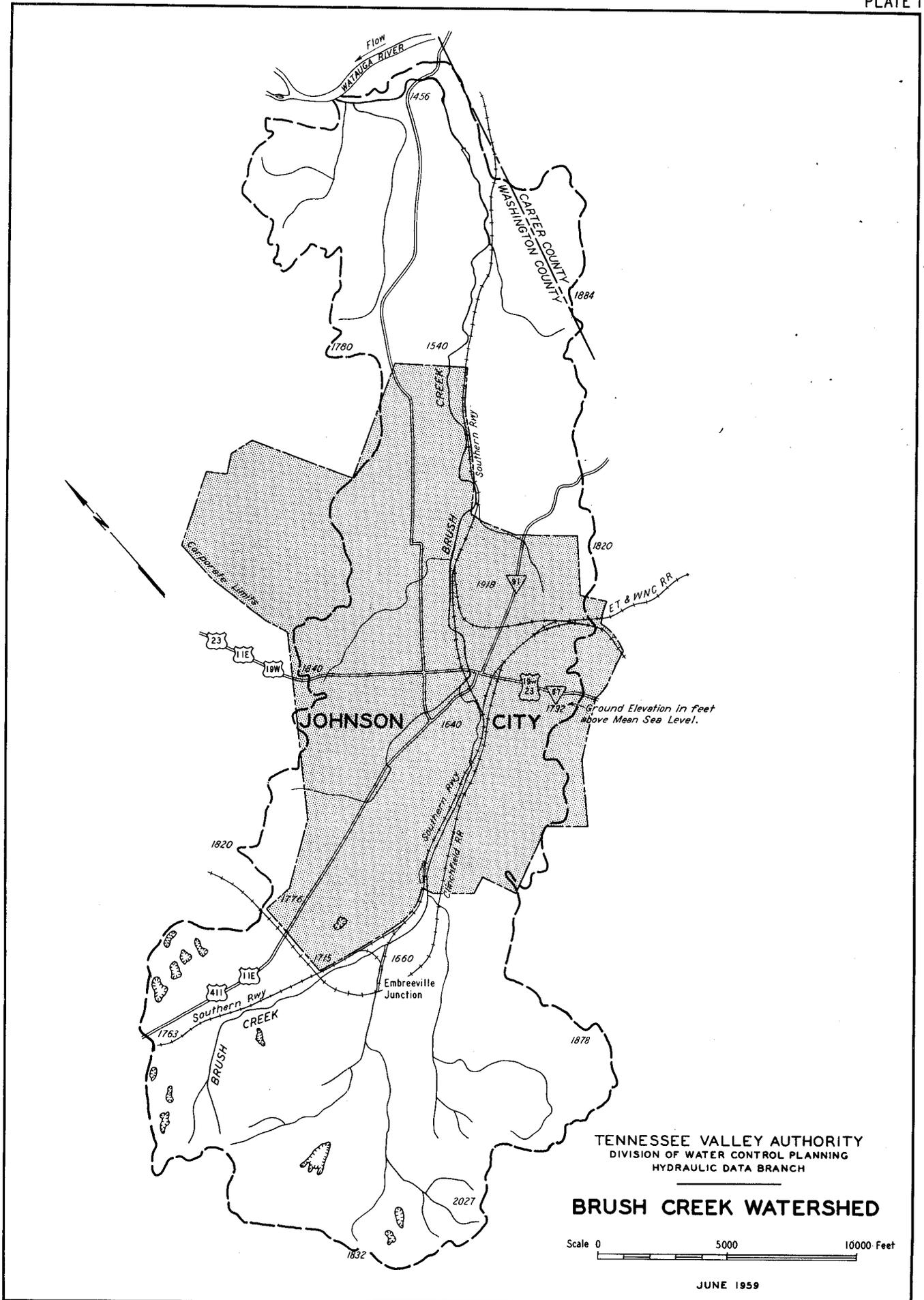
The first post office, known as Blue Plum, was located near the railroad trestle over Sinking Creek, just east of the present city limits. John Hoss Bowman was the first postmaster. He was succeeded by Henry Johnson in about 1850. Johnson had a store and a carding machine shop across Sinking Creek from Bowman's residence. In 1856, during construction of the East Tennessee and Virginia Railroad, now the Southern Railway, Johnson bought a parcel of land from Tipton Jobe and built a brick store at the Junction of the railroad and Market Street, then the stage route from Nashville. He also built a railroad switch and set aside part of the building as a depot. This was accepted by the railroad and Johnson was appointed as agent. The post office was moved to the same place in 1857, and was called Johnson's Tank and later, Johnson's Depot. In 1862 the name of the village was changed to Haynesville in honor of Landon C. Haynes, who had become a senator in the Congress of the Confederate States. On December 1, 1869, the town was granted a charter of incorporation under the name of Johnson City and Henry Johnson was elected as the first Mayor.

The East Tennessee and Virginia Railroad was completed through Johnson City in 1857 and the Clinchfield Railroad followed it fifty-two years later in 1909.

The population of the city has increased from about 400 in 1879 to 27,900 in 1950. The Johnson City Chamber of Commerce estimates the 1959 population to be 29,000. The greatest growth followed establishment of the rayon plants in Elizabethton between 1925 and 1930 when many of the plant workers settled in Johnson City.

The Creek and Its Valley

The Brush Creek watershed shown on Plate 1 is long and relatively narrow with rolling topography most of which is cleared. However, above Johnson City, the area is somewhat fanshaped with three branch streams



TENNESSEE VALLEY AUTHORITY
 DIVISION OF WATER CONTROL PLANNING
 HYDRAULIC DATA BRANCH

BRUSH CREEK WATERSHED

Scale 0 5000 10000 Feet

JUNE 1959

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coming together in the neighborhood of Embreeville Junction to form the main channel of Brush Creek. Drainage areas at pertinent locations are:

<u>Location</u>	<u>Creek Mile</u>	<u>Drainage Area*</u> square miles
Mouth at Watauga River	0.0	16.2
Railroad Crossing	4.6	10.4
Oak Street	5.5	9.4
Sevier Street	6.4	6.7
Embreeville Junction	8.2	3.4

*Sink hole areas in watershed are excluded. At the mouth of the creek, these total 1.1 square miles.

The stream flows generally east from its headwaters to Johnson City where it turns northeast and flows on to its mouth in Watauga River about 3 miles downstream from Johnson City. The elevations of the ridges bounding the watershed range from 1800 to 2000 feet. Elevations in Johnson City along Brush Creek vary from 1560 to 1650. The flood plain elevation near the mouth of the creek is about 1410 feet.

The total fall from the head of Brush Creek to the lower end of the Johnson City business district is about 290 feet. The rate of fall is about 60 feet per mile. From Johnson City to Watauga River the creek falls another 220 feet in 5-3/4 miles. From the Clinchfield Railroad crossing above Embreeville Junction downstream to the point where Furnace Street crosses the creek, a distance of five miles, the total fall is 118 feet. This is a rate of 23.6 feet per mile. The fall through the 0.63 mile of covered section in the city is 14.9 feet, which is at the same rate per mile as the average for the whole reach.

Above Johnson City the creek banks are quite low, averaging only about three feet above low water. Through the covered section, the street levels are generally about six feet above low water.

Large floods overflow the creek banks to widths depending upon the topography of the flood plain. In the upper part of Johnson City above the covered creek section, widths vary up to 500 feet. Through the business district,

floods that exceed the capacity of the covered section may result in overflows up to 1000 feet. Downstream from Furnace Street overflow widths are narrow, only reaching 200 feet. About 2 miles above the mouth, the creek enters a gorge section with little overflow. Near the mouth Watauga River backwater during large floods spreads over the creek flood plain for several hundred feet.

Bridges and Culverts Across the Creek

From the mouth of Brush Creek to the lower city limits of Johnson City at Mile 3.32 there are 2 road bridges and 5 private bridges. Within the city limits of Johnson City there are 16 street bridges, 3 private bridges, and 11 railroad bridges. In the Embreeville Junction section above Johnson City there are 3 street bridges and 3 railroad bridges. This is a total of twenty-nine street bridges and fourteen railroad trestles or culverts in the 8-3/4 miles of creek covered by the investigation. Table 1 lists the floor, clearance, and stream bed elevations at each bridge and culvert, together with the crest elevation of the flood of August 9, 1938. Figures 2 and 3 are views of some of the street and railroad bridges across Brush Creek.

The floor and underclearance elevations for all bridges are plotted on the profile, Plate 5, and are tabulated in Table 1. Many of these structures have underclearance elevations lower than the August 1938 and other high floods.

Covered Sections of Channel

Prior to 1933 and 1934 Brush Creek was covered only by separate buildings and the street bridges. The building over the creek at the lower end of the now covered section, Mile 5.77, was built prior to 1922. The building over the creek downstream from Market Street was built in 1924 and the Arcade Building, between Market and Main Streets, in 1923. The building on the upstream side of Main Street was completed in 1922, prior to the flood in that year. At Wilson Avenue the buildings on the downstream side were built in 1927. Where the creek passes under these buildings, it has not been walled or covered and flow is obstructed by the columns supporting the floors. At the time of the September 1922 flood the city jail was located over the creek on the downstream side of Market Street. This was torn down in 1924 when the Miller Grocery Company store was erected at the same place.



Fairview Street



Broadway



Oak Street
and walled channel downstream



Elm Street



Sevier Street
and pipe obstructing opening



Watauga Avenue

Figure 2. --STREET CROSSINGS OF BRUSH CREEK



Spur crossing half mile above Fairview Street



Southern Railway main line and spur crossing below Broadway



Spur crossing quarter mile above Broadway



Spur crossing above Oak Street



Southern Railway crossing above Watauga Avenue



Spur crossing below Embreeville Street

Figure 3. --RAILROAD CROSSINGS OF BRUSH CREEK

TABLE 1
BRIDGES ACROSS BRUSH CREEK
MOUTH TO MILE 8.77
VICINITY OF JOHNSON CITY, TENNESSEE

Mile Above Mouth	Identification	Stream Bed Elevation feet	Floor Elevation feet	Aug. 9 1938 Flood Crest Elevation feet	Underclearance		
					Eleva- tion feet	Above Aug. 9 1938 feet	Below Aug. 9 1938 feet
0.73	County Rd.	1419.7	1428.8		1425.5		
1.80	Private Rd.	1483.0	1489.9		1488.7		
2.07	County Rd.	1501.8	1509.8	1509.4	1508.4		1.0
2.32	Private Rd.	1509.7	1515.6	1517.0	1514.4		2.6
2.73	Private Rd.	1520.1	1526.5	1529.0	1525.7		3.3
2.74	Private Rd.	1520.1	1526.6	1529.2	1525.7		3.5
3.31	Private Rd.	1538.7	1543.9	1544.4	1542.6		1.8
3.75	Furnace St.	1555.6	1563.5	1562.5	1562.6	0.1	
3.81	Southern Spur	1558.8	1569.3	1564.0	1566.2	2.2	
4.08	Southern Spur	1563.5	1572.9	1569.4	1570.3	0.9	
4.29	Southern Spur	1571.6	1580.5	1578.2	1577.9		0.3
4.31	Private Rd.	1574.4	1577.8	1579.8	1576.6		3.2
4.33	Southern Railway	1574.3	1586.4	1582.3	1583.2	0.9	
4.56	Southern Ry. Main Line	1581.0	1590.5	1589.3	1587.6		1.7
4.56+	Southern Spur	1580.9	1590.6	1589.5	1588.0		1.5
4.65	Broadway	1584.1	1592.1	1590.7	1590.9	0.2	
4.86	Oakland Ave.	1585.5	1595.2	1592.2	1593.4	1.2	
4.88	Southern Spur	1585.5	1596.1	1592.3	1593.3	1.0	
5.19	New St.	1590.8	1601.1	1595.5	1599.2	3.7	
5.46	Oak St.	1596.4	1605.1	1602.3	1604.0	1.7	
5.50	Southern Spur	1599.1	1611.0	1604.8	1608.2	3.4	
5.51	Southern Railway	1599.5	1612.0	1606.3	1609.5	3.2	
5.57	Private Rd.	1602.5	1608.1	1609.2	1606.9		2.3
5.60	Elm St.	1604.0	1612.2	1610.6	1610.8	0.2	
5.72	Private Rd.	1605.7	1614.4	1612.6	1613.5	0.9	

TABLE 1 (Concluded)
BRIDGES ACROSS BRUSH CREEK
MOUTH TO MILE 8.77
VICINITY OF JOHNSON CITY, TENNESSEE

Mile Above Mouth	Identification	Stream Bed Elevation feet	Floor Elevation feet	Aug. 9 1938 Flood Crest Elevation feet	Underclearance		
					Eleva- tion feet	Above Aug. 9 1938 feet	Below Aug. 9 1938 feet
5.86	Roan St.	1609.0	1616.2	1617.4	1614.4		3.0
5.92	Southern Railway	1609.8	1618.2	1617.5	1615.0		2.5
5.96	Commerce St.	1610.6	1616.8	1617.7	1615.0		2.7
6.07	Market St.	1610.7	1617.3	1618.4	1615.3		3.1
6.12	Main St.	1612.2	1618.8	1619.7	1616.8		2.9
6.16	Lamont St.	1612.9	1620.4	1620.9	1617.7		3.2
6.23	Wilson Ave.	1617.6	1626.4	1624.7	1624.6		0.1
6.45	Sevier St.	1622.8	1630.4	1631.3	1629.4		1.9
6.64	Watauga St.	1626.1	1633.4	1634.5	1631.2		3.3
6.68	Southern Railway	1625.7	1635.2	1635.7	1631.8		3.9
7.06	Tennessee St.	1636.8	1644.2	1644.3	1643.4		0.9
7.70	South Gate St.	1651.1	1659.0	1658.9	1657.0		1.9
7.80	Leonard St.	1653.0	1656.4	1659.1	1655.5		3.6
7.92	Lyle St.	1654.6	1660.2	1659.9	1659.0		0.9
8.18	Clinchfield RR Spur	1658.1	1670.4	1666.4	1667.7	1.3	
8.35	Southern Railway Spur	1663.5	1672.6	1669.7	1669.9	0.2	
8.45	Embreeville St.	1665.2	1670.1	1670.3	1668.7		1.6
8.77	Clinchfield RR	1674.0	1715.9		1684.2		

A covered section of channel 2, 610 feet in length through Johnson City, starting at Mile 5.77 and ending at Mile 6.26, was built by the Works Progress Administration in 1933 and 1934. This filled in the gaps between buildings. In 1940 the covered portion was extended about 700 feet farther upstream. Figure 4 shows the entrance and outlet of the covered section.

The 1933-1934 section consists of two rectangular barrels, each 15 feet wide and about 6 feet high. At street crossings, this height is reduced about 1.3 feet by beams supporting the pavement. The Wilson Street bridge is the only exception to the standard bridge construction. This bridge is of the arch type, with a width of 30 feet and a center height of opening of 7 feet. It is estimated that the capacity of this covered section without overflow is of the order of 900 cubic feet per second, which is about 40 percent of the 1938 peak discharge.

The 1940 work was done in connection with construction of a tobacco warehouse. Twenty-eight feet of the creek above the Auto Sales Company was left open. The section here differs from the covered reach below in that there are three rectangular barrels, each 8 feet wide. The top is level and the height of opening varies from 7 feet at the upper end to 10 feet at the lower end.

There is another covered section, 340 feet long, under the Gloria Rayon Mills building just above Embreeville Street. Figure 5 shows the entrance and outlet of this section. The original mill building was constructed in 1927, but the portion over the creek was not built until shortly before the 1938 flood.

At the upper end of the reach of Brush Creek included in this investigation the creek flows under the Clinchfield Railroad embankment in a culvert 102 feet long. Figure 6 shows this culvert. In the flood of August 9, 1938, this culvert was too small to handle the flow of the stream and the water backed up and ponded on the property above the embankment. The situation was aggravated when a small wooden bridge floated across the inlet to the culvert and partially blocked the opening. After that the water backed up and flooded a house, tobacco patch, barn, granary, and farm machinery.

By-Pass Storm Sewer

In 1948, a by-pass sewer was constructed across a loop in the Brush Creek channel beginning 200 feet above Wilson Avenue, Mile 6.27. The by-pass, shown on the maps, Plates 3 and 4, follows along the Southern Railway track

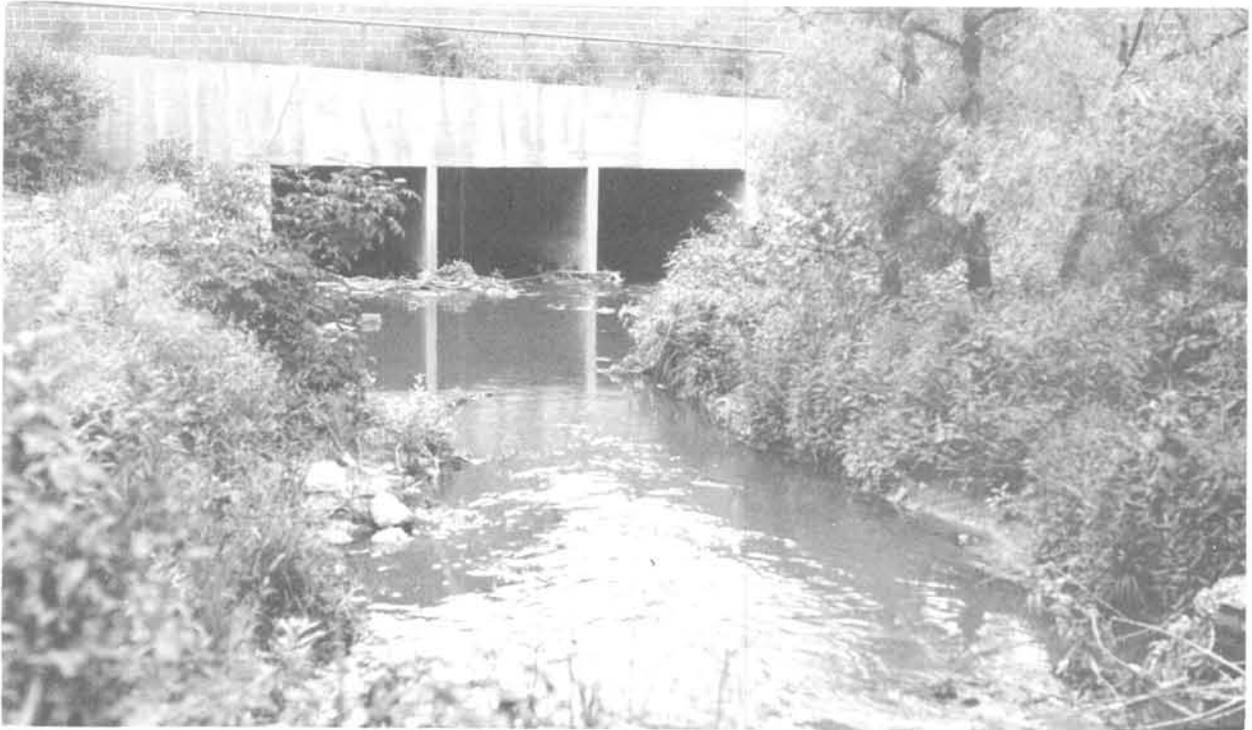


Figure 4. --COVERED SECTION OF CREEK - MILE 6.40 TO MILE 5.77

The upper view is the entrance to the covered section of Brush Creek near Sevier Street. This extends for 3370 feet to the outlet below Roan Street which is shown in the lower picture. Columns supporting buildings over the creek obstruct flow of the creek. The upstream 700 feet of this section was built after the 1938 flood. The lower view shows the height of the 1938 flood, and of the Regional and Maximum Probable Floods discussed respectively in Sections II and III.

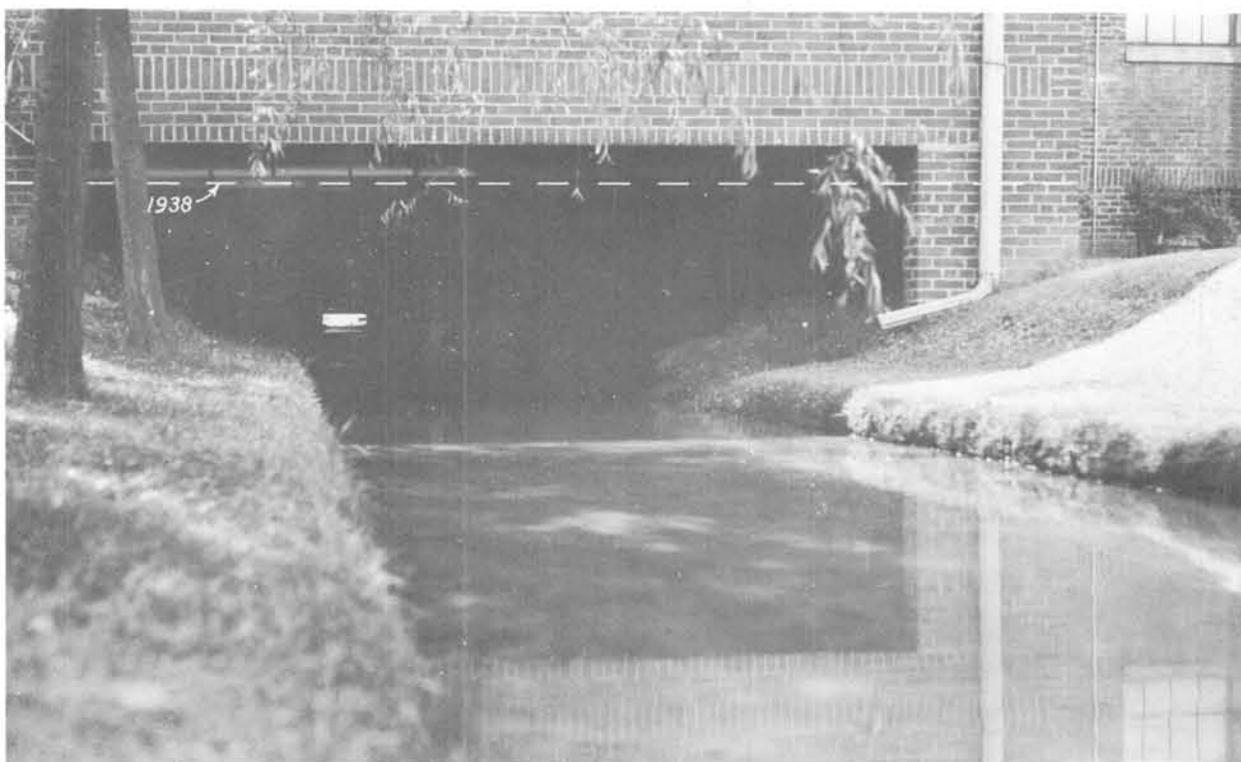


Figure 5. --BRUSH CREEK CHANNEL UNDER GLORIA MILL

The creek flows for 340 feet under the Gloria Rayon Mill. The upper picture is the entrance and the lower picture is the outlet. The lower view shows the height of the 1938 flood.



Figure 6. --RAILROAD CULVERT AT MILE 8.76

Brush Creek flows under the Clinchfield Railroad embankment through a culvert 102 feet long. Large floods would be headed up and flood water ponded on the upstream side of the 16 feet high embankment.

for 1320 feet to an outlet in Brush Creek 30 feet above where the creek crosses under the railroad at Mile 5.93. The by-pass starts as a concrete pipe 4 feet in diameter. Four hundred forty feet downstream a 36-inch diameter storm sewer is intercepted at a manhole. From that point downstream the by-pass is 60 inches in diameter.

This by-pass sewer is an asset in providing extra water-carrying capacity in a limited reach of Brush Creek. However, in such large floods as those of 1908 and 1938, the effect of the by-pass sewer in lowering flood heights would not be large.

Developments in the Flood Plain

From the head of the reach covered by this report, Brush Creek runs through an area in which the flood plain has been taken over for residential purposes in the upper end and for business purposes through the heart of the business district of Johnson City downstream to Mile 3.75, a total distance of about 5 miles. The map, Plate 3, shows the area in which the flood plain is largely developed. Plate 4 is a detailed map of the business district on a large scale which shows the buildings and other improvements that are on the flood plain through the business district of Johnson City. This plate shows the outline of the flooded area during the August 1938 flood which largely delineates the boundaries of the flood plain through this section.

At the upper end of the reach in the Embreeville Junction region, the flood plain has been used for residences, and one large industry, the Gloria Rayon Mill, is built over the creek channel.

From Mile 3.75 to the mouth, the creek runs through a predominantly agricultural region without any significant developments in the flood plain. This portion of the creek is quite steep and the valley through which the creek runs is narrow and offers little opportunity for development. Near the mouth in the Watauga River, the new Johnson City sewage disposal works has been constructed on an area where the terrain widens out somewhat. Considering the lowering of floods that is effected by TVA's Watauga Reservoir, the elevations of the principal features of the sewage works are high enough so that the operation of the plant would not be interfered with except during floods of much greater discharge than any that have occurred in the past.

Encroachments on Natural Floodway

The descriptions of the developments in the flood plain and of the bridges that have been constructed across the creek make it evident that both the channel and the natural valley of Brush Creek have been encroached upon by works of man which greatly impair the natural flood-carrying capacity of the stream.

At the extreme upper end, the embankment of the Clinchfield Railroad blocks the natural flood flow through the Brush Creek flood plain, and flood water ponds upstream from the embankment so that the actual flood crest through Johnson City is reduced thereby. The effect of the impoundment is that of a small retarding reservoir. The Gloria Mill is built across the creek channel at such an elevation that the underclearance is lower than that of the height of large floods so that the effect is that of obstructing the natural flow. The numerous buildings that have been built over the creek in many cases have columns extending into the creek channel to support the building floors. These have a tendency to collect drift and to otherwise obstruct the free flow of water. The buildings on the flood plain, particularly through the business district, constitute material encroachment on the floodway for discharge of high waters in Brush Creek and materially raise flood heights. In many cases the highway and railroad bridges and trestles that are built across the creek channel have piers or pile bents in the creek channel which obstruct flow and catch drift, particularly during times of high water.

Report of Consulting Engineer O. K. Morgan

On June 21, 1923, Consulting Engineer O. K. Morgan of Johnson City made a report to Mayor W. B. Ellison, "upon which to base recommendations as to proper measures to be taken to prevent serious flood damages to Johnson City from the frequent and sudden rises of Brush Creek."

Although this report is now some 36 years old, it is significant that the following prophetic statements from this report point out the necessity for taking measures to provide adequate waterways for streams and the dangers of obstructing these waterways, all of which is just as applicable today as it was in 1923.

The justification for such a study and such precautions is easily apparent to any one having knowledge of the past and present local situation. The tendency of a population to restrict the space required by streams is well known and apparent in Johnson City as well as elsewhere. Our local conditions grow worse in this respect and the City should at once take measures to prevent further encroachment, to remedy the hazards already existing and to provide for safety of the future, for a stream will not be denied its right to its full area required to carry off its largest flood.

Anyone reading the daily papers cannot fail to be impressed with the growing frequency of flood disasters and wonder why better precautions are not taken. Some claim that the denuding of the forests is increasing the speed with which the water flows from the land and thereby raising the height of flood waters, and no doubt this is true in part. On the other hand the primary cause is the encroachments on the banks and channel ways by industry and commerce and the restriction of areaway, causing the natural flood heights to be higher and the incident damage greater.

Neglect of precautions is frequently followed by loss of life and damages far in excess of the cost of prevention; and unless improvement is made such may recur from time to time and be multiplied again and again.

Mr. Morgan pointed out examples of the truth of his statements by citing floods that had occurred at Hot Springs, Arkansas, Pueblo, Colorado, Dayton, Ohio, Erie, Pennsylvania, Louisville, Kentucky, and Kansas City, Kansas.

Mr. Morgan then continued:

Johnson City has had warning. We have already had four rather substantial floods within fifteen years. On July 4, 1922,¹ and again on August 15, 1922,² also August, 1919, and May, 1908. The May flood of 1908 was the heaviest, but by reason of growth of the town and new bridges and restricted waterways the flood of July 4, 1922,¹ did the most damage and rose higher at many points in the center of the town.

It is doubtful if Johnson City has yet had its largest flood from the standpoint of quantity of water, and the four above mentioned floods can be considered as minor floods in the sense that they were not as large as we may expect. This statement is based on a calculation of the probable amount of former floods as compared with the size of, and probable yield of, the drainage area, as will later be shown.

Experience has shown that we are in a region of heavy downpours where flood conditions are common. Many persons residing here remember the Elizabethton floods of 1901 and 1902, and the concurrent floods at Bakersville, North Carolina, and Keystone, West Virginia; also the Altapass flood of 1916. "Cloud-burst," so-called, are common to this region and liable to occur any time, and if such should occur on the headwaters of Brush Creek it will result in great disaster to Johnson City, unless conditions are remedied. The shape of Brush Creek's drainage area is exceedingly favorable to concentration of waters in the

1. Probably should be September 4, 1922, as no other evidence of a July 4 flood has been found.

2. Probably August 15, 1912, as no evidence has been found of an August 1922 flood.

center of the town, and this situation is further augmented by the grades of the stream which descend with regularity from the very head of the stream to Summer Street, then flatten off over the ledges of limestone to Elm Street, at the Tannery, and then rapidly descend to Oak Street bridge, at Carr's Lumber Yard, below which they again present a fairly regular grade to below Broadway Carnegie.

Further on the report states:

Locally Johnson City's rainfall record goes back to 1905 when a gauge was established at the Soldiers' Home and since then it has been located at several places. 1-3/4 inches is the most ever recorded in 24 hours, but that was one rain lasting for almost two hours and was at the time of the May flood, 1908. Bluff City and Jonesboro records have been kept for more years, but are in another drainage area. These have been studied for such light as they might reveal.

Mr. Morgan's report includes estimated discharges during several past floods including that of 1908 and develops a design for an improved channel that would have a capacity varying from 1680 cubic feet per second at the Tennessee Street bridge to 3,105 cubic feet per second at Roan Street bridge. This plan covered a length of 17,000 linear feet. The works proposed were not constructed, but some 10 years after the Morgan report, the creek was improved by the construction of the covered section by the Works Progress Administration.

FLOOD SITUATION

Flood Records

The U. S. Geological Survey maintained a staff gage on Brush Creek at the Carr Brothers Lumber Company near Oak Street from June 16, 1932, to September 30, 1933. The gage records show no significant floods during this period. A rise on July 20, 1933, reached a stage of 2.70 feet, or 1.7 feet lower than that of August 9, 1938.

Immediately following the flood of August 9, 1938, Hydraulic Data Branch engineers made an investigation of the storm and flood. High water marks and other pertinent data for the flood were obtained. The report covering this investigation describes the rainfall and damages and includes newspaper articles, photographs, isohyetal map, and other data. This report was published in the September 1938 issue of "Precipitation in the Tennessee River Basin."

Contacts With Local Residents and Newspaper Research

In May 1945 and again in 1959, Hydraulic Data Branch engineers made an investigation with respect to past floods on Brush Creek.

Local residents including city officials were interviewed to obtain data regarding past floods. Where information was obtained, reference is made to this in the "Flood Descriptions" which are given further on in this report. Most local people had little recollection of past floods and high water marks for such floods. However, after persistent search a number of marks for the September 1922 flood were found as well as a few for other floods.

Research was carried out in available files of newspapers. Newspapers have been published in Johnson City since 1883 but unfortunately files of the papers prior to 1914 have not been preserved. Some files of the "Staff News" and of the "Johnson City Chronicle" were located in the library of East Tennessee State Teachers College at Johnson City covering the period 1914 through 1944. Complete microfilms of the latter paper were obtained from the Tennessee State Library and Archives of Nashville covering the period January 1949 through February 1959. From the same source microfilms were obtained of a nearly complete file of the weekly Jonesboro "Herald and Tribune" from August 1869 to February 1959.

Careful search was made in the available Johnson City and Jonesboro papers for flood information. However, the Johnson City newspapers made only occasional reference to high waters on Brush Creek, and doubtless many floods passed without newspaper notice. This does not mean that there were no floods but only that the effects on the community were not enough to rate mention in the papers in which competition for space for news was no doubt keen. The Jonesboro paper did report the large flood of 1908 and some others, but obviously only unusually high water on Brush Creek would be newsworthy in the Jonesboro paper.

Information on some floods was found in the files of Knoxville newspapers which were searched for certain periods when heavy rainfall indicated the probability of floods which local papers did not mention.

Flood Occurrences

Table 2 shows the month of occurrence in which there is evidence of floods on Brush Creek. The list is compiled from newspaper references and historical documents, from investigations by Hydraulic Data Branch engineers, and from information gathered from residents of the Brush Creek vicinity. Admittedly incomplete, the tabulation does give a conception of the months in which floods have occurred in the past.

TABLE 2
MONTH OF OCCURRENCE
OF
FLOODS ON BRUSH CREEK

<u>Month</u>	<u>Occurrence</u>	<u>Month</u>	<u>Occurrence</u>
January	0	July	3
February	3	August	4
March	2	September	1
April	1	October	0
May	2	November	0
June	1	December	0
			17

Eleven of these flood occurrences have been during the late spring and summer months from May through September and have come chiefly from intense thunderstorm rainfall. About a third of the floods have been winter floods resulting from general rains.

Flood Discharges

An estimate of the 1938 flood peak discharge was made by Hydraulic Data Branch engineers immediately after the flood in a reach just above the Auto Sales Company at creek Mile 6.4.

In the report of Consulting Engineer O. K. Morgan, discharges for several floods are given. The basis for these estimates is not known but the discharges appear to be generally harmonious with the estimate of the 1938 flood made by Hydraulic Data Branch engineers.

The several discharges are given in the following Table 3.

TABLE 3
ESTIMATED FLOOD DISCHARGES
ON
BRUSH CREEK

<u>Date</u>	<u>Location</u>	<u>Mile</u>	<u>Drainage Area sq. mi.</u>	<u>Peak Discharge</u>	
				<u>Amount cubic feet per second</u>	<u>Per Square Mile cubic feet per second</u>
May 29, 1908				1,980*	
Aug. 15, 1912				1,800*	
Aug. 1919				1,700*	
Sep. 4, 1922				1,750*	
Aug. 9, 1938	Above Auto Sales Co.	6.4	7.5	2,200	294

*From report by O. K. Morgan, Consulting Engineer, 1923. Location of discharge measurements not known. Hence, discharges are not directly comparable with that of 1938.

Effect of Backwater from Watauga River

The greatest known flood on Watauga River occurred in May 1901 prior to the construction by TVA of Watauga Reservoir. At the mouth of Brush Creek, the Watauga River flood waters at that time reached elevation 1418.5 and backwater from the river would have extended overbank up Brush Creek for about a half mile. With TVA's Watauga Reservoir in operation, this flood would be reduced to elevation 1404.5 at the mouth of Brush Creek and backwater would extend upstream only about a quarter mile.

The highest elevation that would occur on Watauga River at the mouth of Brush Creek in the event of a maximum probable flood on Watauga River as controlled by Watauga Reservoir would be 1416.8. This would extend upstream on Brush Creek about four-tenths of a mile as shown on the profile, Plate 5.

Rate of Rise and Velocities

Brush Creek above Johnson City has steep slopes and a relatively narrow flood plain, as previously described. During floods as large as that of August 9, 1938, it is estimated that velocities in the creek channel through Johnson City were on the order of 7 to 9 feet per second. In the bottom land at the upper and lower limits of town the velocities were estimated to have been about 5 to 7 feet per second during the 1938 flood.

No specific information is available concerning the rate of rise of floods on Brush Creek. However, the slope of the stream and the small size of drainage area are factors which indicate that the creek would rise to overbank crests in large floods in a few hours, following which the creek would fall rather rapidly.

Flooded Area in August 1938

Plate 3 shows the area inundated by the flood of August 9, 1938, on Brush Creek. This area has been determined from high water marks and field inspection of the flooded area immediately after the flood. The culture on this plate is that for 1939 and some changes and developments have been made since that time. The limits of overflow shown on Plate 3 have been determined using flood profile elevations, valley cross sections, and the topography as shown on the map. The boundaries of the overflow area as defined by these means are sufficiently accurate for the intended purpose but the actual limits of overflow on the ground may vary somewhat from that shown. This is because the contour interval of the map, which is 20 feet, does not permit precise plotting of the flooded area boundaries. To define these limits with a higher degree of accuracy would require costly surveys which present purposes do not warrant.

Plate 4 is a large-scale map of the Johnson City business district showing the area overflowed by the August 9, 1938, flood. This shows the covered section of the creek and particularly the buildings over the creek and in the flood plain. The by-pass sewer along the Southern Railway is also shown on this plate.

Flood Profile

On Plate 5 is shown the high water profile for the flood of August 9, 1938. Also shown are several high water marks for the flood of September 4, 1922,

and one mark for the May 29, 1908, flood. Profiles of low water, of the bed of the creek, and of top of bank are shown. Indicated on Plate 5 are floor and under-clearance elevations at bridges crossing the creek. The 1938 profile has been developed from the high water marks obtained by TVA Hydraulic Data Branch engineers immediately after the flood from silt and trash lines left by the flood. High water marks for other floods were obtained from contacts with local people who witnessed the floods or had information about these. Profiles for the Regional Flood and the Maximum Probable Flood discussed in Sections II and III, respectively, of this report are shown.

Valley Cross Sections

Plate 6 shows 8 typical cross sections of Brush Creek and the lands along the banks. These were selected from 27 cross sections taken by TVA's Hydraulic Data Branch engineers for use in the engineering studies made for this report. The location of all the cross sections is shown on the map, Plate 3, and the profile, Plate 5. The cross sections not reproduced are available to anyone who may have need for them from TVA's Hydraulic Data Branch.

Each cross section shows the elevation and limits of overflow (1) of the flood of August 9, 1938, (2) of the Regional Flood discussed in Section II, and (3) of the Maximum Probable Flood discussed in Section III of this report.

Profiles along Market and Main Streets

Plate 7 shows profiles along the center line of Market and Main Streets across the flood plain of Brush Creek. Floor elevations of buildings along one side of the street are shown as well as the barrel of the Brush Creek covered section under the street. This plate shows the height and limits of overflow for (1) the flood of August 9, 1938, (2) the Regional Flood discussed in Section II, and (3) the Maximum Probable Flood discussed in Section III of this report.

FLOOD DESCRIPTIONS

The following descriptions cover the floods that are known to have occurred on Brush Creek in the vicinity of Johnson City for which information is available. The flood descriptions are based on investigations made by TVA Hydraulic Data Branch engineers, on information furnished by local residents, and on research in newspaper files and historical documents for accounts of past floods. In the absence of actual records of stream heights and discharges, local residents, diaries, histories, and newspaper accounts are the best available sources of information covering past floods. Each newspaper account has been reviewed to present material that appears to give a correct portrayal of the flood being reported.

Early Floods

There are no definite records of floods on Brush Creek prior to 1901. However, it is known that great storms occurred on several occasions over the area in which Brush Creek is located and in all probability large floods occurred on that stream the same as they did on other streams in the region. One of the best sources of knowledge concerning such early floods in the upper East Tennessee region is a diary kept by Robert P. Fickle of Blountville in Sullivan County.

Mr. Fickle refers to "a great tide sometime in 1790." He mentions 1817, 1835, 1847, 1848, and 1851 as years in which large floods occurred on streams in the upper East Tennessee region. On September 15, 1861, he wrote, "A tide was made by a hard rain which continued for four or five days with intermissions of 6, 12, and 24 hours. This tide was the height of the tide in 1817 and somewhat higher." In 1862 on February 21, "Commenced raining steadily and rained without any intermission on the twenty-first and on during the night following until daylight on the twenty-second. . . . This tide was about 2 feet higher than the tide of 1861. This was a general tide throughout the Southern Confederacy. Rain was general throughout the southern states."

In March 1867 Mr. Fickle recorded "The greatest tide yet in Holston River was caused by the most unprecedented raining season known to the oldest people." This was the great storm that caused floods all over the eastern part of the Tennessee Valley and resulted in the highest floods ever known at Knoxville

and Chattanooga. According to Mr. Fickle, "Great damage was done on the rivers and creeks. Bottoms on the river were damaged either by being washed into holes and gutters or covered by sand. Many mills were carried off, also houses, barns, and stables thought to be out of reach of high water."

In February 1875 the Fickle diary notes heavy rains for several days which resulted in "raising the branches more than at any time since the great tide in 1867 . . . great damage was done to property along the water courses and a vast number of rails were carried off."

While none of these flood comments specifically refer to Brush Creek, it is undoubtedly true that on most of these occasions rainfall over the Brush Creek watershed would have been sufficient to have resulted in large floods on the creek. It is quite possible that the great storm of 1867 produced a flood in Brush Creek of greater volume and height than any that have occurred since.

February 1875

This is one of the flood periods mentioned in Fickle's diary. The following clippings from the Jonesboro "Herald and Tribune" indicate that a flood did occur on Brush Creek at this time.

Thursday, March 4

THE FRESHET

The damage caused by the late freshets which have continued for the last nine days has been the principle topic with all. In this immediate section of country the waters have perhaps not been quite as high as they were eight years ago last month, but in some portions in East Tennessee, they have been much higher and done greater damage. Throughout this county the principle damage was in washing away the fences in the valleys and lowlands, carrying away the soil from hillside fields that were plowed during the fall and winter seasons, and washing the public highways so that it is impossible for wagons and teams to pass over them. Many small bridges have washed away, but they can soon be repaired. . . .

Thursday, March 11

JOHNSON CITY ITEMS

The effects of the freshet are still seen in our town. It will probably be several days until the town looks like it did before the rains came. Several bridges were washed away, and fences went in every direction almost. . . .

May 23, 1901

"The Knoxville Sentinel," Thursday afternoon, May 23, 1901, carried the following brief account of a flood on this date:

FLOODS DESTRUCTIVE WORK IN UPPER EAST TENNESSEE

.

Brick Yard Was Overflowed

Special to the Sentinel.

Johnson City, Tenn., May 23. --The sawmill and lumber yard of J. W. Cardwell in the Fourth Ward was flooded and much damaged by the high water of Brush Creek.

The Jonesboro "Herald and Tribune," Wednesday, May 15, 1901, carried the somewhat facetious account of this high water.

THE VINELAND DISTRICT

The 8th and 9th gave us three dashing rains, one of them charged with buckshot hail that whitened the ground and crippled tender vegetables a little. The three rains gave an aggregate of $3\frac{1}{2}$ inches of water; each one came as such a sudden dash that not much was absorbed by the ground, and rushed off the surface causing serious washes in the fields.

Well, what does Jonesboro mean? Is it prospecting for a place as a seaport town? Our information is that at the close of one of our recent rains, the river (what's its name?) was well up to the courthouse, Presbyterian church and one of the hotels.

No late definite word from Johnson City; but the presumption is that their "Brush Creek Ocean" was billowy indeed, and possibly some damage done to their inter-oceanic Nicaraguan canal.

May 29, 1908

This is the largest known flood on Brush Creek at Johnson City. At that time the rain gage for the Johnson City area was at Jonesboro. Rainfall recorded there was only 2.35 inches for the storm. This rainfall is rather meaningless and only shows that the intense part of the storm that caused the Brush Creek flood did not extend to Jonesboro. News accounts indicate that

the flood resulted from a "cloudburst in the mountains near Johnson City" and that "the cloudburst . . . was entirely a local affair."

Mr. Sam R. Taylor of the Johnson City Furniture Company moved to Johnson City when a boy in 1901. For several years thereafter he lived in a house on the northwest corner of Market and McClure Streets, now the site of a store called "The Little Market." Mr. Taylor stated in May 1959 to a Hydraulic Data Branch engineer that the greatest flood he had seen on Brush Creek occurred in 1908. He remembered that the water just reached the floor level of their home and estimated that the floor was $2\frac{1}{2}$ feet higher than the street level which he believes has not changed appreciably. He recalls that Main and Market Streets crossed the creek on timber bridges and that both washed out during the flood. As the Main Street bridge floated by his home it almost hit the porch of the house.

Mr. Taylor did not believe that the 1908 flood was much higher than the 1922 and 1938 floods, but he thought that there was much more water in 1908 since the flood plain was not crowded with buildings. He remembered that there were about three residences, two livery stables, one brick building and one large frame building in the Main and Market Street area between the railroad tracks and Boone Street. The present City Hall building was built about 1907, and across Market Street was a large frame building known as "The White Elephant." Many of the present buildings were built after the 1922 flood, which Mr. Taylor believed to be about the same height as the 1938 flood which got two feet deep in his present store on Main Street.

The Jonesboro "Herald and Tribune," Wednesday, June 3, 1908, reported this flood in the following account.

**RAIN AND CLOUDBURST SENDS BRUSH CREEK HIGHER
THAN IT HAS BEEN IN 35 YEARS, HOUSES FLOODED
AND WASHED AWAY BUT THE OCCUPANTS WERE RESCUED**

Johnson City, Tenn., May 29. --A terrific rain and cloudburst west of this city this afternoon raised Brush Creek fully twelve feet and West Main Street was flooded for fully three hundred yards. Probably the biggest damage was to the Standard Oak Veneer and Allen Panel Companies. Water completely covered the plants including the stockroom. The loss is placed at \$10,000 with no insurance.

Many cottages and a few small store buildings had to be vacated. Many occupants who had lingered were safely rescued. Most of the smaller cottages were toppled over or swept away. Many of the big buildings and warehouses were flooded. Especially were the

stocks in the warehouses damaged. T. E. Hurst had a car and a half of sugar watered; H. W. Pardue totally lost 3,000 pounds of flour and had two carloads of sugar watered; Coca Cola Bottling works was damaged \$500. M. I. Gump's cellar was flooded and Saturday was near an end when all the water was pumped out. His loss will be several hundred dollars. He had oils, vinegar, crocks, etc., stored in his cellar. The Watauga Electric Company was damaged several hundred dollars. Water got in the machinery and the lights did not flash forth until about 10:00 o'clock. The ice company's loss will aggregate \$200.

The Watauga Tannery, Johnson City Foundry and Machine Shops suffered about \$300 damages. The Embreeville branch of the Southern railroad was badly washed for eight miles. Many bridges were damaged and much track was torn from the ties.

"The Journal and Tribune," Knoxville, Saturday, May 30, 1908, gave the following account of this flood:

**RAIN AND CLOUDBURST SENDS BRUSH CREEK
HIGHER THAN IT HAS BEEN IN 35 YEARS AND
REACHING FLOOD STAGE AT JOHNSON CITY
HOUSES FLOODED AND WASHED AWAY BUT THE
OCCUPANTS WERE RESCUED**

Special to The Journal and Tribune.

Johnson City, Tenn., May 29. --A terrific rain and cloudburst west of this city this afternoon raised Brush Creek fully twelve feet and West Main Street was flooded for three hundred yards. Houses were flooded but the occupants rescued. Cars were stopped and many turned out to view the waves. It was the highest stage that had been seen here in thirty-five years. Several cabins were washed away and the Standard Oil Company lost several hundred empty barrels.

Another Account of Johnson City Flood

Bristol, Tenn., May 29. --The worst flood in the history of Johnson City, Tennessee, visited that city late this afternoon, causing much damage. Several of the business streets centering at the Southern Railway station were flooded with water and the loss is heavy. The railroad bridge near the station was washed away and as a result traffic is still blocked on the main line of the Southern. Several whole sale houses, the electric plant and other concerns suffered heavy loss on account of the high water.

"The Journal and Tribune," Knoxville, in the following two accounts shows that this flood was caused by an intense cloudburst type of storm that covered only a small area but did much damage:

Saturday, May 30, 1908

EIGHT BRIDGES SWEEP AWAY AND SIX MILES OF TRACK DESTROYED BY CLOUDBURST - EMBREEVILLE BRANCH OF SOUTHERN TERRIBLY DISFIGURED BY THE STORM

The flood following the cloudburst in the mountains near Johnson City Friday wrought terrible havoc to the Embreeville Branch of the Southern Railway, almost washing that short line out of existence.

No less than eight bridges and six miles of track were swept away by the flood, according to the official report made to Southern Railway officials. The bridges destroyed are all small structures and the big bridge across the Nolichucky on the Embreeville Branch was not damaged. However, the damage is so extensive that it will require several days to repair it and there will be an extensive delay before traffic will be resumed on the Embreeville line.

No particulars or details concerning the damage done were contained in the reports made to the officials in this city other than that the eight bridges were swept away and that about six miles of track went with them. Southern officials went out to the scene of the damage last night on a hand car. The report of the damage was received in this city about eight o'clock last night.

No damage was done to the main line of the Southern and there was no interference with traffic further than that slow orders were sent over the wires as is always done when there are heavy rains.

The Embreeville Branch is twelve miles, running out from Johnson City. No passenger trains are handled over the short line, the mail and passenger business being handled on a local freight train.

Sunday, May 31, 1908

EMBREEVILLE LINE REPAIRS BEING RUSHED FORWARD BY LARGE FORCE OF WORKMEN - TRAFFIC ON THE SHORT LINE MAY BE RESUMED MONDAY - BRIDGE LOSS SEVERE - - (No New Information Or Damages) - -

The cloudburst which did the damage was entirely a local affair. No other part of the Knoxville division reported any damage at all.

The Jonesboro "Herald and Tribune," Wednesday, June 10, 1908, viewed the 1908 flood in retrospect in the following story.

BRUSH CREEK (COMMUNITY)

Our section has its share of events but they are not often reported.

The great freshet or cloudburst which occurred the 29th of May has been a common topic ever since. The marks which have been made from time to time show that this creek has never been so high. The damage to corn fields is considerable as much of the soil is removed. The lowlands were entirely inundated and some crops were buried out of sight. The most important event, in connection with the great rain, was the destruction of a barn and some fruit trees which was wrought by a funnel shaped cloud which passed through this immediate section. Several persons witnessed the wonderful display of electric power. This cloud was, perhaps, not larger than a big ballon yet it moved near the earth with irresistible force. One large cherry tree and several apple trees which were in its track were lifted out of the earth. A tree was carried bodily for some distance and dropped in a wheat field. Every object which was struck by this little cyclone was given a whirling motion. The last assault it was seen to make was on John Saylor's barn near the summit. The building was lifted from the earth allowing a horse and calf to escape unhurt. The barn in falling was crushed like an egg shell and the spirit of the storm moved on, no one knows whither.

1910 or 1912

In reporting the flood of September 4, 1922, the "Johnson City Daily Staff," Tuesday, September 5, 1922, stated:

Yesterday's flood was the third deluge descending upon the town in the last ten or twelve years. Three years ago in August a portion of the downtown district was inundated when Brush and King Creeks overflowed their banks. The first of the three "high tides" occurred in either 1910 or 1912.

This indicates a high flood in either 1910 or 1912. There is some evidence that this flood occurred August 15, 1912.

July 16, 1916

The high water in Johnson City at this time resulted from the great tropical hurricane of July 1916 that precipitated heavy rainfall over much of the eastern Tennessee Valley and caused devastating floods over large areas in that general region. Rainfall of 22 inches was recorded in 24 hours at Altapass, North Carolina, during this storm. Numerous amounts of over 20 inches

occurred along the eastern rim of the Tennessee Valley. The main portion of the flood-producing rainfall came in a 12-hour period. Due to the concentrated intense rainfall, a heavy percentage of the rainfall ran off into the streams.

Although the extremely heavy rainfall was on the Atlantic Coast side of the high mountains in the eastern Tennessee Valley, there was considerable carry-over of storm rainfall beyond the mountains into the region on the west side of the mountains of which the Brush Creek watershed above Johnson City is a part. At the Johnson City Weather Bureau gage, the rainfall measured 2.72 inches on July 16, 1916. Probabilities are that the rainfall on the watershed of Brush Creek above the city was greater than this.

The "Johnson City Staff," Monday, July 17, 1916, carried the following account of the July flood in East Tennessee:

TERRIFIC FLOODS IN EAST TENNESSEE

East Tennessee, Western North Carolina, and Southwest Virginia have been deluged with rains during the past thirty-six hours and as a result thousands of dollars worth of property have been damaged, and farm lands in many sections have been totally devastated by the floods, the crops having been completely washed away or buried with soil and debris. This is particularly the case in the river valleys and lowlands. No loss of life is reported.

The rains were the hardest that have fallen in these sections since the May flood of 1901 when so much property was washed away. The rivers at many points have only lacked a few inches or feet of reaching the high mark at this time.

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The Watauga and Chuckey Rivers reached a high stage Sunday afternoon and as a result farm lands were badly washed and crops in some instances entirely ruined.

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The rain in Washington County and Johnson City was the most severe that has been witnessed in years and as a result incalculable damage has been done to the farm lands, especially to corn and late hay crops. In Johnson City a number of buildings especially on West Main Street were flooded by the high waters. The Coca Cola Company on West Main Street and the Jones-Vance Drug Company at the corner of Tipton and Buffalo Streets were perhaps the worst flooded.

August 1919

This flood is mentioned in the September 5, 1922, "Johnson City Daily Staff" by the following reference:

Three years ago in August a portion of the downtown district was inundated when Brush and King Creeks overflowed their banks.

Mr. O. K. Morgan, in his report, refers to this as a "substantial" flood on Brush Creek.

July 4 and August 15, 1922

The only reference to floods on these dates is in the report of Consulting Engineer O. K. Morgan. The Johnson City papers do not mention floods on these dates but do report the September 4, 1922, flood. The Morgan report, written in 1923, makes no mention of the big September 1922 flood. It would be reasonable to assume that typographical errors in the Morgan report have resulted in incorrect references to these floods and that the July 4 flood mentioned by Morgan should be September 4, and the August 15, 1922 flood should be August 15, 1912. Such interpretation would be in conformity with other information.

September 4, 1922

The "Johnson City Daily Staff," Tuesday, September 5, 1922, gives the story of this flood in the following account:

**HEAVY DAMAGE DONE BY FLOODS
WHICH SWEPT SECTION OF CITY**

Real Cloudburst Experienced Here Monday Afternoon. Brush and King Creeks Went on Rampage. Basements Were Flooded and Foundations Washed From Under Houses. Trucks Used to Carry People From Homes on King Street. Many People Lost Quantities of Canned Fruits - Horses Saved From Scott Livery Barn But Much Hay Carried Down in Flood

With the subsidence of the flood that descended upon the city late yesterday afternoon and swirled in a yellow backwash over the

streets and invaded the basement of many business and dwelling houses near the confluence of Brush Creek and its tributary, King Creek, the estimated damage to property sustained a corresponding revision downward.

The torrential rain commencing about 3:30 lasted an hour and a half. Paved streets converging into the business district carried the flood like mill races into the natural basin formed near the Southern Railway intersections with West Main and West Market Streets, quickly submerging portions of the thoroughfare in that region. Further west along Main and Market, King Creek liberated from classic Potlicker, which received its quintennial bath.

Business houses on Commerce, Boone, West Market and West Main were surrounded by water which caused property owners considerable inconvenience. A survey of the flooded area this morning after the high waters had completely subsided revealed but negligible damage to property. Many basements remained practically filled and in a few of the stores certain kinds of stocks were water soaked. Each individual was careful to guard his property, however, with the result that merchandise was protected.

The booby hatch astride of Brush Creek was the first municipal institution to be surrounded by water. When the tide crept out of its natural creek bed channel, the jail matron, watching the onrushing water anxiously from a vantage point on the bridge nearby, warned the Chief of Police that there were two prisoners in the jail. She herself set the Chief an example by wading bravely through water and rescuing a mentally afflicted woman who had been held for a few days awaiting authorization from Virginia officials. The Chief said he thought the water wouldn't come much higher. Half an hour afterward, he commandeered a dray wagon and rescued the marooned inmate. The water by that time was lapping the concrete floor of the well-known city building. Farther out the street at police headquarters the yellow peril lapped the concrete ground floor invading the hall of justice - - - .

Out on West Market near the Cherokee region life guards exerted themselves fishing for a small herd of a half dozen tethered cows. It was reported that one cow met a tragic death in a watery grave but the rumor could not be verified this morning. Dr. J. N. Elder, the city food and dairy inspector, was investigating the affair today. The loss of one cow brings the number of town cows down to 499 according to Dr. Elder's estimate.

The city jail furniture and household effects were exposed to the bright sun rays by the jail matron this morning. Two or three quilts, as many chairs, the water pitcher and municipal silver were included in the display.

The floor of the water department in the Municipal Building was several inches under water. The auto chemical truck pumped the basement reservoir dry today.

From the Cherokee Flats to Red Row near the Cranberry Furnace in Carnegie, waterway dwellers suffered the inconveniences of the flood. Many of the residences resembled houseboats. Standard Oil Company truck drivers were this morning returning barrels washed from the yard at the intersection of Bowman Street and the Southern Railway.

Water collecting in the excavation for the Clinchfield-Slim Gage and Division Street underpass caused a delay of railway traffic when it was found that the sidewalks had crumbled under the tracks. The damage done there was considerable.

Yesterday's flood was the third deluge descending upon the town in the last ten or twelve years. Three years ago in August a portion of the downtown district was inundated when Brush and King Creeks overflowed their banks. The first of the three "high tides" occurred in either 1910 or 1912. It is remarkable that trouble from storm waters began to multiply with the paving of many streets and the increasing numbers of buildings along them.

On King Street the flood waters surrounded a number of residences and the many foundations under these houses were crushed in by the heavy waters. Trucks were sent to some of the residences in this section and women and children moved to higher ground. Many of the residents lost all of their canned fruits, jellies, and other winter edibles which they had prepared only a few weeks before.

The horses in the Scott Livery stables across Brush Creek were removed from their stables but not until much of the flooring under the barn had been washed out and considerable hay had been carried down in the flood. Stable men worked in water waist deep for hours in caring for the horses and in getting the buggies and other vehicles to higher ground.

June 1932

Photographs obtained in 1938 by Hydraulic Data Branch engineers from the Burr Harrison Studios in Johnson City show a flood which occurred in the summer of 1932, probably just prior to installation of the staff gage by the U. S. Geological Survey in June. Elevations estimated from these photographs show that the flood was almost identical with that of September 1922. No newspaper references were found for this flood and no data have been located regarding this flood other than the photographs, two of which are reproduced in Figure 7.



Figure 7. --SUMMER FLOOD IN 1932

The upper view is along Buffalo Street looking toward the intersection with Tipton Street. The lower view is looking west on Market Street from the Arcade Building.

(Photos by Burr Harrison Studio, Johnson City)

August 9, 1938

The second largest flood known on Brush Creek in Johnson City occurred on August 9, 1938. Late on the night of August 8 a storm of considerable magnitude and intensity occurred over the drainage area of Brush Creek. By 2:00 a. m. of August 9 several business blocks in Johnson City were under flood waters and the creek had overflowed its banks and spread over the adjoining flood plain.

The rainfall occurred between 9:00 p. m. and midnight of August 8. Engineers from the Hydraulic Data Branch of TVA made an investigation immediately following the flood. In addition to the rainfall observed at Johnson City, the engineers determined how much rain fell in the upper watershed by locating catches in vessels that happened to be exposed to the storm. Amounts varied from 2 inches to 6 inches over the watershed of Brush Creek upstream from Johnson City.

The cover of this report shows the flood near its crest in the Johnson City business district, and Figure 8 shows two views taken immediately after the flood on which the flood crest height is indicated.

The flood caused approximately \$25,000 worth of damage to Johnson City and the area along the creek above the city. No damage occurred below the city. A door-to-door canvass was made by Hydraulic Data Branch engineers in the business and industrial sections of Johnson City to determine the total damage to the various individual business concerns. Almost 40 houses were affected by the flood. Most of them were in the "Y" section near Embreeville Junction and the remainder along King and Market Streets in the city. None of them were damaged insofar as the buildings were directly concerned but in several instances the furniture in them suffered damage.

The portion of the city that was flooded has few storage basements. Most of the basements are merely large enough to house the furnaces. The major portion of the furnaces were cast iron since practically all of the heating systems were either hot water or low-pressure steam. Thus, the only damage suffered was slight damage to the insulation and cost of cleaning the mud from the furnaces.

The Johnson City fire chief stated that flushing the mud from the streets and pumping the water from the basements cost the city about one thousand dollars.



Figure 8. --THE MORNING AFTER THE 1938 FLOOD

Upper view shows Main Street entrance to Arcade Building. At the crest, the water came to within 2 inches of the glass in the doors. This building is set over the creek, and water flowed through the building during the flood. The lower view is a filling station near the highway underpass of the Clinchfield Railroad near the Soldiers' Home. The man is pointing out the flood height at the crest.

Damage to streets and highways in the area was small since the flood was of such short duration that little erosion occurred. The Southern Railway suffered damage due to ballast being washed from the roadbed but the Clinchfield Railroad suffered little damage.

Due to the alertness of the police and fire departments of Johnson City, damages were greatly reduced. The police and firemen phoned practically all of the merchants in the affected area and notified them of the flood. The merchants in many cases were able to dam out the water and in most instances the elevation of the water inside the buildings was at least one foot lower than in the streets and alley adjacent to them. Many devices were used to prevent the water from entering the buildings. One grocery man built a temporary dam by using sacks of flour as though they were sand bags. In doing this about \$20 worth of flour was destroyed but several hundred dollars worth of merchandise was saved. Such methods were practical because the water remained at crest stage but a few minutes and the leakage through the temporary dams across doorways did not continue long enough to fill the stores.

The "Johnson City Chronicle," August 9, 1938, reported the flood of a few hours earlier as follows:

HIGH WATER ROARS OVER LOWER CITY

Waters from a torrential rain beyond the Y section roared down Brush Creek shortly after midnight and flooded large portions of the downtown section early today.

The extent of the damage to flooded Y section and to downtown business firms could not be estimated until the waters subsided.

At 2:10 this morning, the muddy, over-flowing Brush Creek was still pouring water in the lower parts of the city along the Southern railway. A preliminary check showed the lower floors of stores bordering on Main and Market streets, Buffalo were covered.

The water level had reached the top of wheels on several cars parked downtown. Boxes, crates, and a variety of rubbish could be seen floating down streets, alleys, and through the arcade building. News of the high water brought growing crowds.

At 2:15, water had covered Market Street beyond Boone and was still rising.

City buses were marooned on the old Jonesboro road. While one was towed in by a wrecker, calls began to pour into police headquarters and fire stations from drivers of disabled cars, asking assistance.

Families were reported evacuating in the southwestern (Y) section of the city, where a creek bounded out of its banks and swept through the low structures to the terror and discomfort of the inhabitants.

Southern train No. 18 was delayed for almost one hour after reaching the section at the South gate of Mountain Home, the crew afraid to proceed for fear the deluge had washed out the railroad tracks.

The engineer had been warned of the terrific downpour in this area when he stopped at Greeneville, and so neither the crew nor passengers were alarmed when the train encountered the tracks covered by rushing and swirling waters.

Barrels and other objects were seen floating, and a railroad signal post at Watauga crossing was pulled from its concrete mooring by the tug of the waters.

"The Knoxville Journal," August 9, 1938, carried the following news story of the flood:

CLOUDBURST INUNDATES AREA IN JOHNSON CITY

Families in "Y" Mill Area Evacuate
As Brush Creek Overflows; No
Casualties Reported Early Today

Johnson City, Aug. 9. (Tuesday)--Numbers of families were evacuating their homes in the "Y" section of Johnson City and water stood knee deep in the business district after a heavy cloudburst.

The heavy rainfall of several inches struck the city shortly after midnight and authorities were checking early today to determine whether there had been any fatalities.

Creek Overflows

Brush Creek, which runs through the business district and the "Y" industrial section of the city overflowed its banks, causing 25 or more families to flee their homes.

Water stood several feet deep in many of the homes and at least 40 or 50 uptown business houses were partially flooded.

Water covered the main line at the Southern railway through the city and train No. 18, New Orleans-New York special, was delayed an hour as engineers cautiously negotiated the flooded section. Train crews waded along the water-covered tracks preceding the train with crowbars examining the track and cross ties. It was feared that

some of the ties may have washed out. No damage was found, however.

Water flowed two feet deep on Main, Market and Buffalo streets, three of the city's principal business streets.

The flooded section near Brush creek is in the western part of Johnson City near the city limits on the Jonesboro road.

Scores of automobiles were marooned, and water was several inches deep inside vehicles. The city's transportation was virtually at a standstill after most of the transit buses were "drowned out" or marooned by the rapidly rising waters in the streets.

Authorities said early today no fatalities had been reported but viewed with alarm the possibility inasmuch as the cloudburst occurred at night without warning. They pointed out that some persons may have been trapped in their homes and drowned before they could flee to safety. No homes were known to have washed away, however.

Johnson City authorities made an appeal to the Washington county sheriff's staff at Jonesboro for aid. They were en route to Johnson City early today to aid families in evacuating and in saving cars and other property marooned by the flood.

The cloudburst was confined principally to the Brush Creek vicinity, although rainfall was reported elsewhere in the city.

The "Johnson City Chronicle," August 10, 1938, summed up the flood in the following account which incidentally estimated damages at about four times the actual.

FIREMEN BUSY BLOTTING TRACES OF \$100,000 CITY FLOOD COSTS

Score Returns to "Y" Section Homes
As Raging Creek Recedes; Many
Stores In Business Area Suffer

Fire Chief L. L. Geisler said last night firemen would be kept busy for several days yet erasing vestiges of the Brush creek overflow from a cloudburst which resulted in estimated damage of \$100,000 to parts of Johnson City's business and residential sections and forced a score of families to evacuate their homes late Monday night and early Tuesday morning.

Men began working in the early morning hours and continued last night pumping out cellars and cleaning off streets.

City Engineer William O. Dyer said that today would be devoted to exploring under buildings such as the Arcade, where Brush creek flows underneath, to see if logs or other debris have lodged.

Phones Impaired

Morgan W. Cox, manager of Inter-Mountain Telephone company, reported 25 "wet" phones, caused by dampness in buildings, were looked after yesterday.

Damage in the business district was confined principally to Market street, especially at intersections with Boone, Commerce and McClure streets, and to West Main and Buffalo streets, where water entered store buildings and stood to a depth of approximately three feet.

Residential sections hardest hit were the low-lying areas in the Y section, near which the cloudburst appeared to originate, and in the juncture of West Watauga avenue and Bowman street. An estimated 20 families were obliged to move out of small houses in each of these areas, but most of them had moved back yesterday afternoon, Geisler said.

No Lives Lost

The heavy rain not only caused firemen to be summoned to duty but also called out deputy sheriffs and city police to lend aid in rescuing families from threatened buildings and to do life-saving work, if that proved necessary. Rumors were current that several persons had been drowned, but officers said these were without foundation.

Six Feet Deep

Assistant Fire Chief George Wilson, a veteran Johnson City resident, said the water in the Y section and on Bowman street was higher than he had ever before seen it. "It stood at least six feet in that part of town," he said.

Estimates Lacking

Geisler estimated that Miller's and the Johnson City Trading company, a West Main street furniture store, received more damage than any other business houses. Exact estimates of the dollars-and-cents loss of the various business houses, however, were not available.

Several boats were paddled up West Market street at the height of the "flood," about 2 a. m. West Main street buildings suffered from the heavy volume of water which poured through the Arcade building, connecting West Main and West Market, and ran in through the front doors of the West Main street structures.

A West Market street grocery barricaded its front door with several barrels of flour and managed to hold down its loss by water.

Although it covered West Market street, water from the creek barely made its way to the 100 block of East Market. A cab company and one or two fruit stands had a few inches of water on their floors. The Windsor hotel and a near-by shoe shop were about the farthest points east on West Main which received damage, although all stores on the low ground of Buffalo street received varying quantities of water.

Service Disrupted

The Washington County Gas company's service was disrupted for a few hours, but was resumed early this morning. Electric power also was interrupted for a few minutes.

At the crest of the flood, the water level reached the top of wheels on several cars parked downtown, and boxes, crates and all kinds of rubbish floated down streets and alleys. City buses were marooned on the old Jonesboro highway and one was towed in by a wrecker. Jonesboro, however had no rain.

The proprietor of the Arcade Tailor shop reported his entire stock was ruined by mud and water.

July 14, 1949

The Johnson City "Press-Chronicle," Friday Evening, July 15, 1949, reported a minor flood.

Streams were swollen some from yesterday's intermittent showers, but no damage was reported. However, in many sections of Johnson City and nearby areas, many basements were reported flooded with water.

July 28, 1951

The Johnson City "Press-Chronicle," Sunday Morning, July 29, 1951, reported flooding in Johnson City without specific reference to Brush Creek. The creek, however, doubtless experienced a small flood. Rainfall in Johnson City for the storm period was 2.17 inches.

Storm struck its second blow within recent weeks at Johnson City yesterday afternoon flooding streets and disrupting electric and telephone service throughout the area.

Sewer Lines Overflow

Sewer lines failed to stand the overflow and streets became streams.

The six-inch depth of water on High Street poured over lawns and gardens on East Unaka and East Watauga Avenue.

Houses in the 800 and 1100 blocks of East Watauga Avenue were almost standing in water. Lawns and gardens became swimming pools. Water in one lawn was about two feet deep.

Water was about a foot deep in lawns in the 300 block of West Watauga and up to the hub caps of cars on Tennessee Street. Some cars were flooded out.

Water poured from the creek on East Tennessee State College campus. The asphalt pavement buckled under the pressure on Tennessee Street.

Flood water washed rocks over Cherokee and Southwest streets. Storm sewers were overloaded and manholes gushed like fountains.

Corn felt the storm's impact in the "Y" section with many crops bowled over. There was little water damage noted here.

The storm story was as always--the rains came and Johnson City buckled under the onslaught--but the storm ended within a few hours.

March 18, 1955

From two accounts in the Johnson City "Press Chronicle" comes the following story of conditions which indicate a flood on Brush Creek.

Friday, March 18, 1955

The rain which swelled area streams, was due to end Friday afternoon.

The heavy rain of Thursday night and early Friday morning is keeping most streams in the area much higher.

Saturday, March 19, 1955

Raging waters of swollen streams throughout the Upper East Tennessee area left banks Friday in several places, flooding lowlands and isolating at least one home.

Streets Covered

Many streets and low areas throughout Johnson City were covered with water Friday afternoon, but probably the greatest damage occurred in Carter County.

February 18, 1956

The "Press-Chronicle" (Johnson City), Saturday, February 18, 1956, carries this story of minor flooding.

The weatherman said 1.50 inches of rain fell in a 24-hour period ending at noon yesterday, with more rain to come.

Water stood in many lowland areas in and around Johnson City yesterday, and streets were covered with running streams of water.

April 15, 1956

The Johnson City "Press-Chronicle," Monday, April 16, 1956, told of this flood which particularly affected the "Y" section in the west end of the city.

Incessant rains of Saturday night and yesterday caused heavy damage to crops, gardens, highways and homes in Washington County and nearby areas.

In Johnson City most of the damage lay in Maupin Row section, where from 15 to 20 families face a possible evacuation if more rain continues today.

Water from Sinking Creek overflowed its banks and rose almost up to the doors of many homes in the Maupin Row section. Basements were flooded and gardens washed out. One unpaved street resembled a river. Water rose about four feet over the street. One unidentified car was stalled in the midst of the stream.

Residents of the area said this was the third time within the past few months that flood waters had endangered their homes.

In other lowlands of the city, basements were flooded, with gardens and lawns suffering from too much precipitation.

High waters from Brush Creek threatened homes in the "Y" section in the west end of the city. Water reached the back porches of several homes, but none were reported in immediate danger. At the underpass west of East Tennessee State College, water stood at car running-board depth last night. All water was receding today.

August 19, 1956

The "Press-Chronicle" (Johnson City), Monday, August 20, 1956, reported this flood in the following account:

Johnson City and nearby areas were visited by a heavy rain and electrical storm about noon yesterday and again last night.

Most of the damage was reported in the "Y" section, where an estimated 50 to 75 homes were surrounded by water. Water entered some of the homes.

Referred to as a "small cloudburst" the washing waters also heavily damaged gardens. At some points on the old Jonesboro Highway in the same section, water stood about three feet deep.

The highway was closed to traffic for about two hours or until the water receded.

Minor damage, except for the washing rain, was reported in other areas.

ACKNOWLEDGMENTS

This section of the report has been prepared by personnel of the Hydraulic Data Branch, Division of Water Control Planning, under the general direction of Reed A. Elliot, Chief Water Control Planning Engineer, and the immediate supervision of Albert S. Fry, Chief, Hydraulic Data Branch. This report was prepared by the Branch Chief assisted by other members of the Branch.

Field investigations were made under the direction of James W. Beverage, Head of the Field Investigations Section. High water investigations in the field were carried out by District Engineer Paul Clark, assisted by Area Engineer Edmund S. Daly.

Under the direction of Paul C. Spath, Head of the Hydraulic Investigations Section, the cover, charts, and maps for the report were prepared by the Office Engineering Unit under Thomas C. Bounds. Newspaper research was carried out by John Scott of the Hydraulic Investigations Section.

The report, including the Preface and Sections I, II, and III, was typed for reproduction by Jean H. Baldwin under the direction of Elizabeth G. Breeden, Head, Administrative Unit. Photographs were prepared for reproduction by Robert Forbes of the Engineering Administration Section.

II.
REGIONAL FLOOD
ON
BRUSH CREEK

Tennessee Valley Authority
Division of Water Control Planning
Hydraulic Data Branch

II.

REGIONAL FLOOD ON BRUSH CREEK

Large floods have been experienced in the past on streams having drainage areas comparable in size to that of Brush Creek in the general geographical and physiographical region of Johnson City, Tennessee, as a result of heavy rainstorms that have occurred over the watersheds of these streams. Such storms, except for the vagaries of the weather, could just as well have occurred over the Brush Creek watershed. Had they done so, floods would have resulted on that creek comparable in magnitude to those that happened on the neighboring streams. It is therefore desirable in connection with any determination of floods that may occur on Brush Creek in the future to consider floods that have occurred on streams in the Johnson City region whose watersheds are similar in physical characteristics to the Brush Creek watershed. Such characteristics include both topography and watershed cover.

Maximum Known Regional Floods

Table 4 contains a list of the maximum floods that are known to have occurred on streams in the region of Johnson City whose drainage areas are not larger than that of Brush Creek. The region considered in this report includes those streams whose watersheds lie in the Great Valley between Maryville, Tennessee, and Saltville, Virginia, distances of 100 miles to the southwest and 50 miles to the northeast from Johnson City. Although in the outskirts of the Appalachian Mountains, the topography of the Brush Creek watershed is moderately rolling and similar to that of the Great Valley. For this reason those more rugged watersheds that lie both to the northwest in the Cumberland Mountains and to the southeast in the Appalachian Mountains have not been considered since streams in those locations differ materially in watershed characteristics from that of Brush Creek.

TABLE 4
MAXIMUM KNOWN FLOODS ON STREAMS IN
GENERAL REGION OF JOHNSON CITY

Map Refer- ence No.	Stream	Location	Drainage Area sq. mi.	Peak Discharge		
				Date	Amount cfs	Per Square Mile cfs
1	Third Creek	at Knoxville, Tenn.	16.7	May 31, 1909	8,500	509
2	Little Chucky Creek	nr Radar, Tenn.	16.2	June 28, 1947	5,000	309
3	Pistol Creek	at Maryville, Tenn.	13.5	February 1875	7,800	578
4	Richland Creek	nr Nolichucky Dam, Tenn.	11.5	June 28, 1947	3,370	293
5	Gass Creek	nr Greeneville, Tenn.	7.9	June 28, 1947	2,510	318
6	Carr Creek	bel Bouton, Va.	7.55	May 25, 1939	3,780	501
7	Brush Creek	at Johnson City, Tenn. (1)	6.7(2)	August 9, 1938	2,200	328
8	Pistol Creek	ab Maryville, Tenn.	6.14	January 7, 1946	1,600	261
9	N. Fk. Moccasin Creek	nr Hansonville, Va.	4.13	May 25, 1939	4,450	1,080
10	Sinking Fork	nr Witt, Hamblen Co., Tenn.	3.02	July 16, 1949	2,570	851
11	Carr Creek	nr Bouton, Va.	2.81	May 25, 1939	3,000	1,070
12	Williams Creek	at Knoxville, Tenn.	2.24	July 10, 1939	1,550	692
13	Cedar Branch	nr Saltville, Va.	1.51	July 5, 1936	5,600	3,700
14	Bailey Branch	nr Hales Cross Roads, Hamblen Co., Tenn.	1.28	July 16, 1949	1,940	1,520

(1) At Mile 6.4 near Wilson Street bridge.

(2) Not included is 0.9 square mile with no surface drainage.

The earliest storm for which the peak discharge on any stream is given in Table 4 is that of February 1875. At that time, record floods were experienced on many streams between Chattanooga and Knoxville. Pistol Creek near Maryville (No. 3 in Table 4) experienced a great flood as a result of rainfall of almost 8 inches in about 48 hours. Another intense storm occurred in May 1909 in the vicinity of Knoxville which caused the highest discharge known on Third Creek (No. 1 in Table 4).

More recently, intense thunderstorms in May 1939 and July 1949 caused big floods on small watersheds in this region. The storm of May 25, 1939, in which 5 to 6 inches of rain fell in 90 minutes, caused record floods on several streams in the vicinity of Hansonville, Virginia, including Carr Creek (No. 6 and No. 11), and North Fork Moccasin Creek (No. 9). The storm of July 16, 1949, near Morristown, Tennessee, when 3.1 inches of rain occurred in about two hours, caused large floods on Sinking Fork (No. 10), and Bailey Branch (No. 14).

Of particular interest is the flood on July 5, 1936, on Cedar Branch near Saltville, Virginia. This flood resulted from an intense cloudburst type of storm in which 5 to 6 inches of rain fell in less than an hour. The storm centered over the small watershed of Cedar Branch, a tributary of North Fork Holston River about three-fourths of a mile east of Saltville, Virginia. Runoff from this intense storm on the watershed area of 1.51 square miles was very large. Two frame buildings near the mouth of the branch were demolished and several sheds and garages were wrecked. Five automobiles were washed down the branch, three going into Holston River. The flood waters and debris which were brought down resulted in washing out of the bridge near the mouth of the stream. The high discharge and accompanying swift velocities resulted in heavy erosion of the water course and the bringing down from the hillsides of debris, rocks, and gravel. This storm and flood in a small watershed illustrates the force and potential--perhaps catastrophic--damages that are inherent in such violent storms and floods. The watershed of Brush Creek above Johnson City is small enough so that it is subject to heavy intense rainfall such as occurred on the Cedar Branch watershed. In such an event, Brush Creek would experience a flood much larger than any so far known.

The floods listed in Table 4 have all occurred on physically similar watersheds in the general region of Johnson City. This indicates

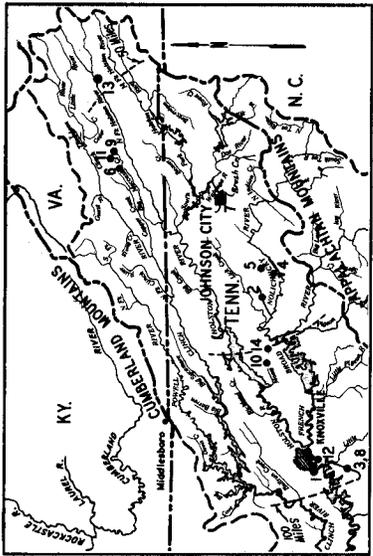
that floods of like magnitude, modified to take into account differences in significant drainage area characteristics, may occur in the future on Brush Creek.

Brush Creek vs. Regional Flood Discharges

The flood discharges in Table 4 have been plotted on Plate 2. This plate shows graphically for drainage areas of various sizes the maximum flood discharges that have been experienced on streams in the Johnson City region. The key map on Plate 2 shows the locations of the streams for which flood discharges are given in Table 4. Included on Plate 2 and in Table 4 is the discharge of Brush Creek for the flood of August 9, 1938.

The flood of May 29, 1908, is the largest that is known to have occurred in about 85 years on Brush Creek. The peak discharge for this flood was evidently somewhat greater than that for the second largest known flood, that of August 9, 1938, which was estimated from measurements made by Hydraulic Data Branch engineers immediately after the flood. However, it is evident that the peak discharges for both of these floods is considerably less than that which has occurred on neighboring streams, particularly Pistol Creek, Carr Creek, and Cedar Branch. These floods are indicative of the magnitude of floods that have been experienced in the Johnson City region and that may be expected on streams in this region in the future.

Based on a consideration of maximum flood discharges that have been experienced in the region of Johnson City, it is reasonable to expect future flood peak discharges in the order of magnitude of those given in the following Table 5. A flood of this magnitude is designated as a Regional Flood. The profile for this flood is shown on Plate 5.



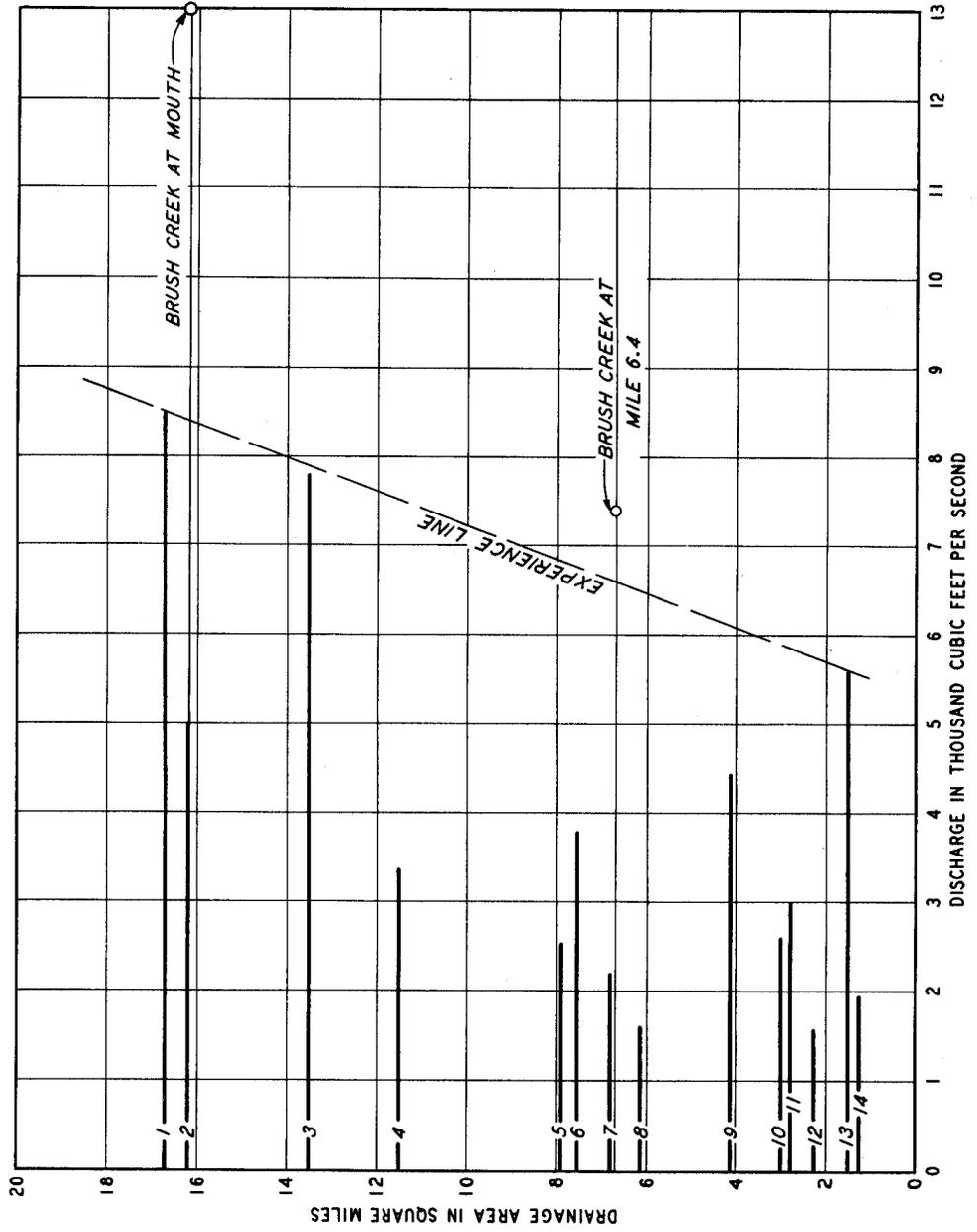
KEY MAP
Scale 0 20 40 60 Miles

Numbers on chart refer to those on Key Map and in Table 4.
O--- Estimated Maximum Probable Flood determined by Flood Control Branch.

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

**MAXIMUM KNOWN
FLOOD DISCHARGES**

REGION OF
JOHNSON CITY, TENNESSEE
JUNE 1959



ASF-1311

TABLE 5
REGIONAL FLOOD DISCHARGES
FOR BRUSH CREEK

<u>Mile</u>	<u>Drainage Area*</u> square miles	<u>Discharge</u> cubic feet per second	<u>Location</u>
8.2	3.43	6,000	Head of reach
6.4	6.71	6,600	Head of covered section
5.5	9.38	7,100	
4.6	10.4	7,300	
2.0	13.7	7,900	

*Excludes area of sink holes.

Figures 9 and 10 show the height that would be reached by the Regional Flood at prominent places in the Johnson City business district.

Flood Heights for Various Discharges

The peak discharge for the flood of August 9, 1938, has been estimated as 2,200 cubic feet per second at the head of the covered channel section, Mile 6.4. In order to show the height of floods greater than that of 1938, Table 6 has been prepared.

TABLE 6
RELATIVE FLOOD HEIGHTS FOR VARIOUS DISCHARGES
BRUSH CREEK AT JOHNSON CITY, MILE 6.4

<u>Date of Flood</u>	<u>Estimated Discharge</u> cubic feet per second	<u>Feet above 1938 Flood</u>
August 9, 1938	2,200	0.0
Regional Flood	6,400*	6.5
Maximum Probable Flood	7,400*	7.5

*Flows reduced 200 and 300 cubic feet per second, respectively, to allow for storage above Clinchfield Railroad.



Figure 9. --MAXIMUM PROBABLE AND REGIONAL FLOOD HEIGHTS IN FOUNTAIN SQUARE AREA

The upper view is west along Market Street from the Southern Railway crossing. The lower view is south along the Southern Railway and Windsor Street from the south end of the station platform. The white circles and dashed lines show the height of the Maximum Probable Flood discussed in Section III. The Regional Flood height is 10 inches lower.



Figure 10. --FLOOD HEIGHTS AT HOTEL AND POWER BOARD BUILDING

The upper view shows the John Sevier Hotel on Roan Street. The lower view shows the Johnson City Power Board building. The white circles and dashed lines are at the height of the Maximum Probable Flood discussed in Section III. The Regional Flood height is 10 inches lower.

Acknowledgments

This section of the report has been prepared by personnel of the Hydraulic Data Branch, Division of Water Control Planning, under the general direction of Reed A. Elliot, Chief Water Control Planning Engineer, and the immediate supervision of Albert S. Fry, Chief, Hydraulic Data Branch. The flood studies were made under the general direction of Willard M. Snyder, Head of the Hydrology Section, by Roger P. Betson. This section of the report has been prepared by the Branch Chief assisted by other members of the Branch. Photographs in this section were taken by TVA photographer Ralph W. Hickle.

III.

MAXIMUM PROBABLE FLOOD

Tennessee Valley Authority
Division of Water Control Planning
Flood Control Branch

III.

MAXIMUM PROBABLE FLOOD

The preceding sections have told about the floods that have already occurred on Brush Creek in the vicinity of Johnson City and of large floods that have occurred on other streams close to Johnson City. This section describes the basis for the Maximum Probable Flood that may reasonably be expected and discusses the extent of the flood plain that would be affected by this flood. Floods of this magnitude are of the kind considered in the design and operation of protective works, the failure of which might be disastrous.

Extreme floods on Brush Creek in the vicinity of Johnson City, with a drainage area of 16.8 square miles at the mouth and 7.2 square miles at the southern city limits, may result either from intense rainfall during winter storms of fairly long duration when infiltration and other losses are generally small, or from intense, short-duration storms or cloudbursts, usually occurring in the summer or early fall when loss rates are generally high.

DETERMINATION OF MAXIMUM PROBABLE FLOOD

In determining the Maximum Probable Flood on Brush Creek consideration was given both to great storms and floods that have already occurred on this watershed and to great storms and floods which have occurred elsewhere but could have occurred on this area. This procedure helps to overcome the lack of hydrologic data in the relatively short period for which dependable records are available.

Section I stated that the maximum known flood on Brush Creek occurred in late May 1908 and the second highest known flood occurred in August 1938. Peak discharge for this latter flood is estimated to have been

2, 200 cubic feet per second at Mile 6.4. It is reasonable to expect that floods greater than that of 1938 will occur on Brush Creek.

Observed Storms

Observed storms are meteorologically transposable to the Brush Creek watershed from within a broad region extending generally from Oklahoma and Nebraska to the Appalachian Divide and from the Great Lakes to the middle of Mississippi, Alabama, and Georgia. 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 Brush Creek watershed, appropriate adjustments were made for differences in this moisture potential.

Table 7 lists known rainfall depths for several large storms transposable to this watershed.

TABLE 7
SELECTED MAXIMUM OBSERVED STORMS

<u>Date</u>	<u>Location</u>	<u>Duration</u> hours	<u>Area</u> sq. mi.	<u>Rainfall</u> <u>Depth</u> inches
September 1926	Iowa	6	10	15.1
July 1938	Tennessee	1	4.5	7.5
August 1938	Tennessee	3	27	11.0
June 1939	Virginia	2	1	9.5
July 1939	Kentucky	3	10	21.0
September 1940	Oklahoma	6	10	18.4
July 1942	Pennsylvania	6	10	24.7
August 1943	West Virginia	3	10	11.0
June 1952	Tennessee	3	Point	10.5

On the basis of these and other data, as adjusted for conditions in the watershed, a rainstorm of 16.8 inches in 6 hours was adopted for computing the Maximum Probable Flood at the mouth of Brush Creek and 18.7 inches in 6 hours at the headwaters. Storms greater than that which would produce the Maximum Probable Flood can occur. Storms up to 50 percent greater than that adopted for the Maximum Probable Flood are possible from a meteorological standpoint.

Observed Floods

When considering peak discharges on other streams, factors such as the meteorology of the region and flood-producing characteristics of the watershed were given consideration in determining whether their application to Brush Creek would be appropriate. In addition to the floods listed in Table 4 of Section II, the following Table 8 lists peak discharges for observed floods on several streams of approximately the size of Brush Creek. For comparison, the discharge of the August 1938 flood at Johnson City is listed.

TABLE 8
SELECTED MAXIMUM OBSERVED FLOODS ON STREAMS
APPROXIMATELY THE SIZE OF BRUSH CREEK

AT JOHNSON CITY, TENNESSEE

<u>Stream</u>	<u>Location</u>	<u>Drainage Area</u> sq. mi.	<u>Date</u>	<u>Peak Discharge</u>	
				<u>Amount</u> cfs	<u>Per Sq. Mi.</u> cfs
Spivey Branch	Manchester, Ky.	1.51	1956	4,100	2,700
Mooreville Creek	Mooreville, Tenn.	4.2	1939	6,900	1,630
EF Globe Creek	Lewisburg, Tenn.	6.6	1939	16,300	2,470
Sandy Creek	Alloway, Tenn.	11.4	1957	10,600	930
WF Little Pigeon R.	Gatlinburg, Tenn.	14.6	1951	12,000	820
Lewis Creek	Putnam, Va.	15.4	1940	10,700	695
NF Pound River	Wise County, Va.	19.3	1942	11,000	570
Fall Creek	Spring City, Tenn.	21.3	1957	13,300	625
Coal Creek	Coal Creek, Tenn.	24.1	1929	12,100	500
Caney Fork R.	Crossville, Tenn.	25.0	1929	14,300	571
Emory River	Gobey, Tenn.	25.0	1929	21,200	850
Charles Creek	Faulkner Spr., Tenn.	32.0	1952	23,000	720
Whites Creek	Glen Alice, Tenn.	35.1	1957	22,600	644
Brush Creek	Johnson City, Tenn.	6.7	1938	2,200	328

Maximum Probable Flood Discharge

From consideration of the flood discharges in Tables 4 and 8 and of the transposition to the Brush Creek area of outstanding storms which have occurred elsewhere but can occur over the Brush Creek watershed, the peak discharge of the Maximum Probable Flood on Brush Creek was determined to be 13,000 cubic feet per second at the mouth and 7,400 cubic feet per second at the southern limits of Johnson City. The unit hydrograph technique, with appropriate

watershed factors, was used to compute flood flows for transposed storms. One of these factors is the presence of numerous sinks, the drainage areas of which were subtracted from the total area before determining discharges. Net effective drainage areas were 16.2 square miles at the mouth of the creek and 6.3 square miles at the southern city limits. Another watershed factor is the flood-reducing effects of two large railroad fills above town and the long, covered culvert within town.

The peak rate of discharge for the Maximum Probable Flood is about 3-1/2 times that of the flood of August 1938, as estimated at Mile 6.4.

Frequency

The frequency of a flood of the magnitude of the Maximum Probable Flood 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, if at all. The consideration of floods of this magnitude is of greater importance in some flood problems than in others and should not be overlooked in the study of any flood problem. Such floods, because of their extreme rarity and uncertainty of occurrence on a given watershed, need be considered only 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 Profile and Overflow Areas

The crest profile computed for the Maximum Probable Flood on Brush Creek in the vicinity of Johnson City is shown on Plate 5. It was computed using stream characteristics for selected reaches as determined from valley cross sections and the observed 1938 flood profile. Cross

sections were surveyed in 1959. The height of the Brush Creek Maximum Probable Flood profile above elevations already experienced in Johnson City varies between 4 and 14 feet. Small changes in area available for flow along Brush Creek could result in rather large increases in depth of flow mainly because of the critical steepness of the stream.

Figures 9 and 10 show the height that would be reached by the Maximum Probable Flood in Johnson City.

The Maximum Probable Flood profile was estimated rather than computed at the covered section from Mile 5.77 to Mile 6.40. The scope of the study does not warrant the cost that would have been required to compute the effect of obstructions in the covered culvert, variations in its size, and the many closely spaced adjacent buildings.

It is impossible to foretell the destructive effect of velocities (see Velocities and Rates of Rise) on bridges over the stream and other nearby structures. In computing the profile of the Maximum Probable Flood, there was no choice but to assume the survival of all structures. No clogging was assumed at bridges.

The elevations shown on Plate 5 and the overflow areas shown on Plate 3 have been determined as accurately as possible consistent with the basic data, but actual elevations may vary from those shown on the profile and map. The contour interval of the map permits only an approximate plotting of the boundaries of the flooded area. To determine flood elevations and limits with a higher degree of accuracy would require costly surveys and studies that are not warranted.

Velocities and Rates of Rise

During the Maximum Probable Flood, velocities in the main channel of Brush Creek would range from about 2 to about 20 feet per second. In the overflow area, velocities would range from about 1 to more than 8 feet per second. The greatest channel velocity would occur in the constricted section at New Street while the largest overbank velocity would occur near Furnace Street.

The Maximum Probable Flood on Brush Creek at Johnson City at the covered section inlet would rise about 14 feet above low water to its

crest in about 7 hours. The maximum rate of rise would be about 5 feet in 1 hour.

These stream and overbank velocities along Brush Creek, in combination with rapid rate of rise and deep flow, would create an unusually hazardous situation. Fortunately, the duration of flood stages is not long.

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