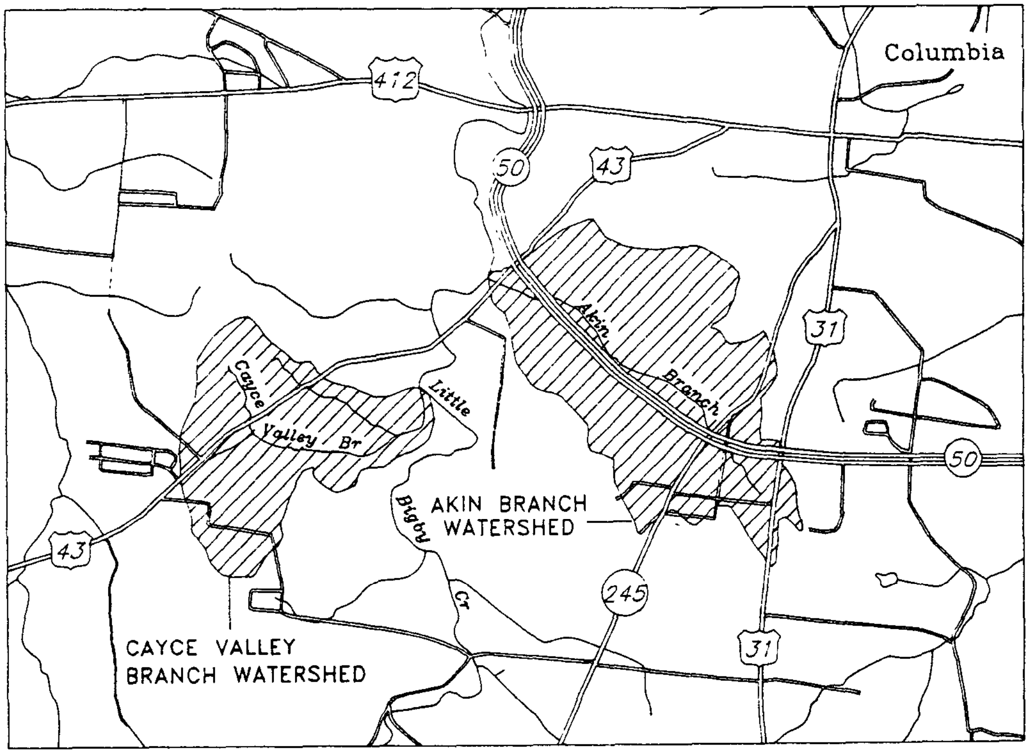
Open-File Report 92-648

Hydrologic and Hydraulic Analyses at Akin Branch and Cayce Valley Branch, Columbia, Tennessee



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Hydrologic and Hydraulic Analyses at Akin Branch and Cayce Valley Branch, Columbia, Tennessee

By GEORGE S. OUTLAW

U.S. GEOLOGICAL SURVEY
Open-File Report 92-648

Prepared in cooperation with the
CITY OF COLUMBIA

Nashville, Tennessee
1993

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	2.540	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square foot (ft^2)	0.0929	square meter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot per second (ft/s)	0.3048	meter per second

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

HYDROLOGIC AND HYDRAULIC ANALYSES AT AKIN BRANCH AND CAYCE VALLEY BRANCH, COLUMBIA, TENNESSEE

By George S. Outlaw

Abstract

The U.S. Geological Survey, in cooperation with the City of Columbia, Tennessee, conducted hydrologic and hydraulic analyses at Akin Branch and Cayce Valley Branch in the Little Bigby Creek watershed, Columbia, Tennessee, from 1990 through 1991. Results of the analyses can be used by city planners in the development of plans to replace several deteriorating and inadequate drainage structures.

Akin Branch and Cayce Valley Branch drain small watersheds of 1.69 and 1.04 square miles, respectively. Flood discharges for 5-, 10-, and 25-year recurrence-interval storm events were calculated at the stream mouths using flood-frequency relations developed for use at small urban streams in Tennessee. For each stream, flood discharges at locations upstream from the mouth were calculated by subdividing the watershed and assigning a percentage of the discharge at the mouth, based on drainage area, to each subarea.

Flood profiles for the selected recurrence-interval flood discharges were simulated for Akin Branch and Cayce Valley Branch for existing conditions and conditions that might exist if drainage improvements such as larger culverts and bridges and channel improvements are constructed. The results of the simulations were used to predict changes in flood elevations that might result from such drainage improvements. Analyses indicate that reductions in existing flood elevations of as much as 2.1 feet for the 5-year flood at some sites on Akin Branch and as much as 3.8 feet for the 5-year flood at some sites on Cayce Valley Branch might be expected with the drainage improvements.

INTRODUCTION

Local flooding due to poor drainage conditions affects many communities in Tennessee. Frequently, local flooding is caused and enhanced by the encroachment of buildings and other structures into natural flood channels, and the constriction of channels at culverts and bridges. Such conditions are present within the Little Bigby Creek watershed of Maury County, Tennessee (fig. 1), and particularly in the urban reaches of two tributaries, Akin Branch and Cayce Valley Branch, in the City of Columbia.

The U.S. Geological Survey (USGS), in cooperation with the City of Columbia, conducted a hydrologic and hydraulic study of Akin Branch and Cayce Valley Branch to determine existing conditions which lead to local flooding, and to evaluate hydrologic and hydraulic conditions that might exist with possible drainage improvements. Objectives of the study were to estimate flood discharges and flood profiles along these two streams for storms with recurrence intervals of 5, 10, and 25 years under present

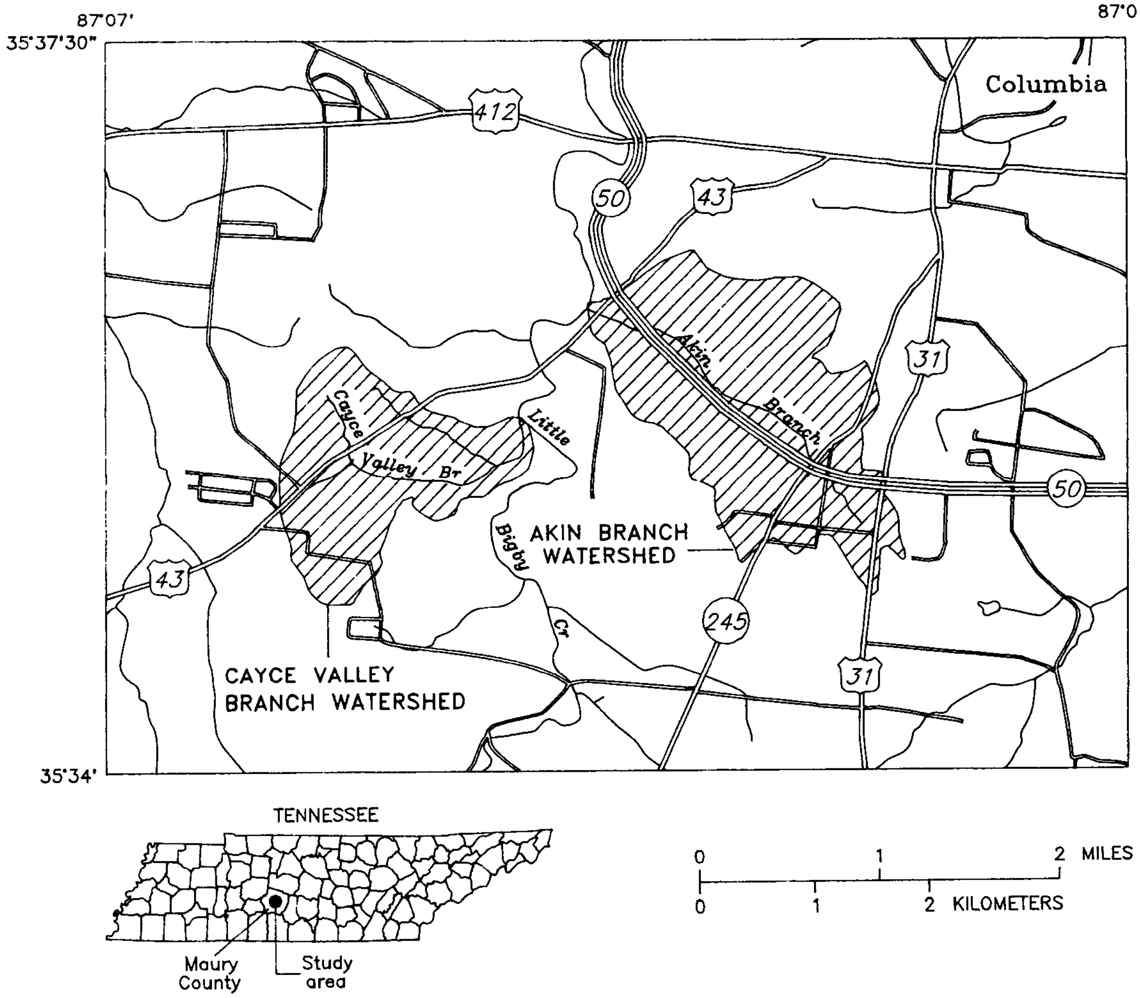


Figure 1. Location of the Akin Branch and the Cayce Valley Branch watersheds, Columbia, Tennessee.

and possible future conditions that include larger culverts and bridges and other channel improvements. The study is one of several urban hydrology investigations being conducted by the USGS in Tennessee and in other states.

Purpose and Scope

This report presents data on the hydraulic characteristics of Akin Branch and Cayce Valley Branch and estimates of flood discharge at numerous points along the streams. The report describes model-simulated flood profiles for 5-, 10-, and 25-year storms, and includes an analysis of changes in flood profiles resulting from possible drainage improvements.

Approach

The following approach was used to meet the objectives of the investigation:

1. The watershed boundary and amount of impervious area within Akin Branch and Cayce Valley Branch watersheds were determined from USGS topographic maps and validated with field data.

2. Hydraulic characteristics of segments of the channels of Akin Branch and Cayce Valley Branch were determined from field surveys. These characteristics included cross-sectional areas, bed profiles, roughness coefficients, and location and dimensions of bridges and culverts.

3. Flood discharges for 5-, 10-, and 25-year recurrence interval storm events were computed for Akin Branch and Cayce Valley Branch using equations developed by Robbins (1984).

4. The USGS Water-Surface Profile (WSPRO) computation model (Shearman and others, 1986; Shearman, 1990) was used to compute flood profiles for 5-, 10-, and 25-year recurrence interval storm events for existing conditions at Akin Branch and Cayce Valley Branch.

5. WSPRO was used to study the effects of drainage improvements at Akin Branch and Cayce Valley Branch.

HYDROLOGIC AND HYDRAULIC ANALYSIS

Flood discharges with 5-, 10-, and 25-year recurrence intervals were estimated at the mouths of Akin Branch and Cayce Valley Branch using regional equations and techniques described by Robbins (1984). For each stream, flood discharges at locations upstream from the mouth were calculated by subdividing the watershed and assigning a percentage of the discharge at the mouth, based on drainage area, to each subarea. Robbins' equations were developed to estimate flood discharges along urban streams in Tennessee with drainage areas from 0.21 to 24.3 mi^2. Using the flood discharges, flood profiles were computed with the WSPRO model. Critical depth was used as the starting elevation for the profile computations. The effects of culverts, bridges, and other obstructions in the channel were included in the computation of the profiles for each flood discharge.

The following equations developed by Robbins (1984) were used to estimate flood discharges.

$$Q_5 = 5.55(A)^{0.75}(IA)^{0.44}(P_{2\_24})^{2.53}$$

$$Q_{10} = 11.8(A)^{0.75}(IA)^{0.43}(P_{2\_24})^{2.12}$$

$$Q_{25} = 21.9(A)^{0.75}(IA)^{0.39}(P_{2\_24})^{1.89}$$

where

Q_n is the estimated flood discharge, in cubic feet per second, for the indicated recurrence interval; n, in years;

A is the area of the watershed, in square miles;

IA is the percentage of the drainage area that is impervious to infiltration of rainfall; and

P_{2_24} is the 2-year 24-hour rainfall, in inches.

Values for watershed area and percentage of impervious area of the watershed were determined using topographic maps, aerial photographs, and field data. The rainfall for the 2-year 24-hour recurrence interval was estimated as 3.6 inches using maps developed for Tennessee by the U.S. Department of Commerce and published by Robbins (1984).

Flood profiles were calculated using the WSPRO model. The model can be used to analyze one-dimensional, gradually varied, steady flow in open channels. WSPRO also can be used to analyze flow through bridges and culverts, and to simulate road overflow.

WSPRO data requirements include: discharge, channel cross sections and distances, bridge and culvert geometry, road surface elevations, and channel-roughness coefficients. Discharges were estimated using equations developed by Robbins (1984). Channel cross sections and distances, bridge and culvert geometry, road surface elevations, and channel-roughness coefficients were obtained from field surveys.

Once the model is calibrated using observed storm data, the hydraulic model can be used to study the effects caused by changes in channel characteristics on the flood profile for a particular flood discharge. For example, changes in the size and aperture of bridges and culverts can be simulated to determine the effects on the flood profiles.

Akin Branch

Akin Branch drains a small urban watershed with a contributing drainage area of 1.7 mi^2. At present, residential and commercial development account for about 10 percent of the basin. However, the potential for continued development could result in 20 percent of the contributing drainage area becoming impervious to infiltration of rainfall in the future. This value of imperviousness was used to estimate flood discharges for future developed conditions.

The study reach (fig. 2) begins at a point approximately 59 feet downstream from the culvert at James Campbell Boulevard (structure 1), and extends upstream approximately 7,300 feet (measured along the centerline of the stream) to a point just upstream from the culvert under the lumberyard at the corner of Highland Avenue and Nicholas Long Drive (structure 13) (table 1). The study reach contains a total of 13 culverts and bridges.

Flood Discharges

Flood discharges for Akin Branch were computed by assigning a percentage of the total basin flood discharge to each basin subarea based on the percentage of the watershed occupied by the subarea (fig. 3). The watershed was subdivided on the basis of topography and the location of tributaries and culverts draining into the creek. Flood discharges for the 5-, 10-, and 25-year recurrence intervals for each basin

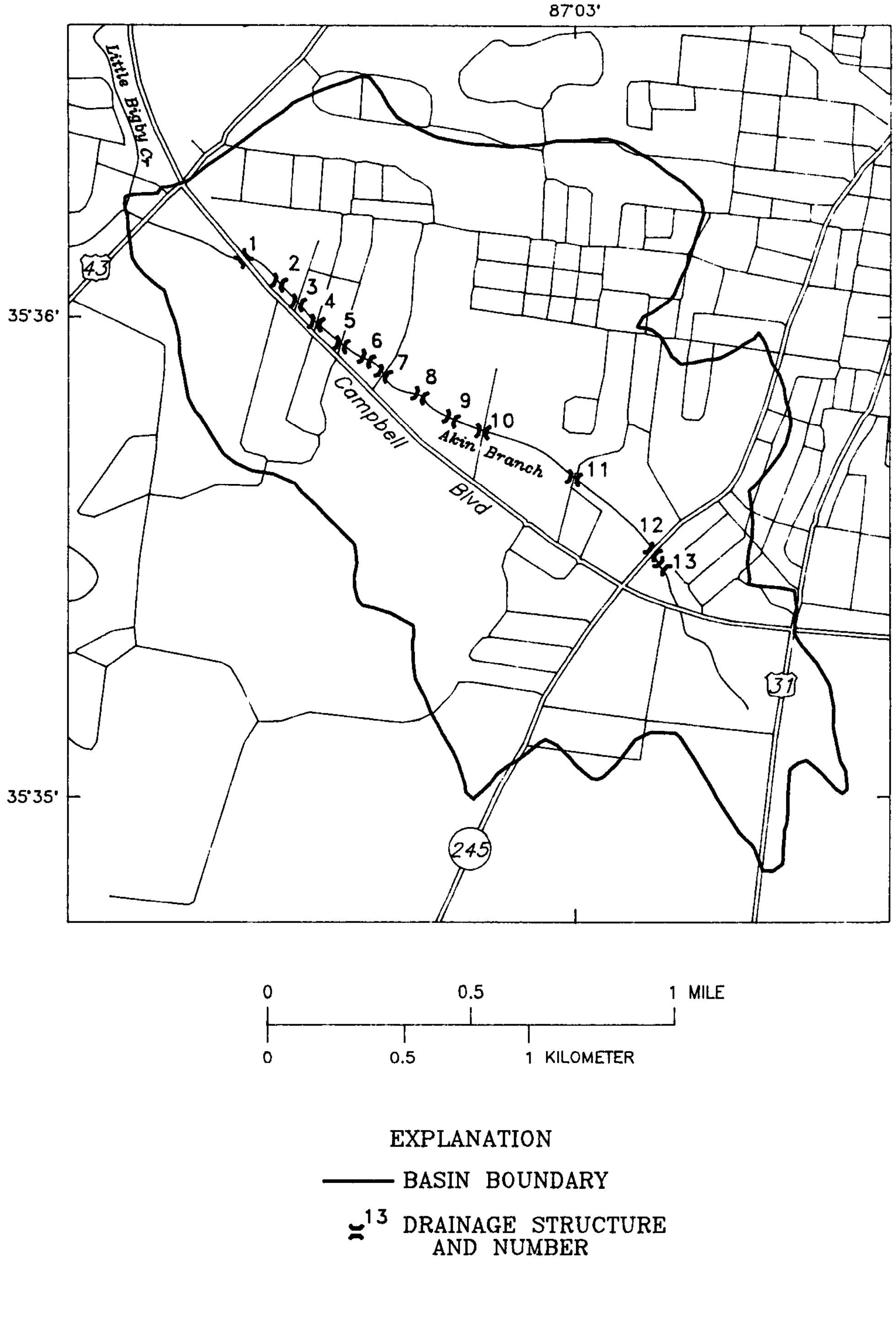


Figure 2. Location of drainage structures in the Akin Branch study reach.

Table 1. Akin Branch culvert and bridge inventory

[Stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

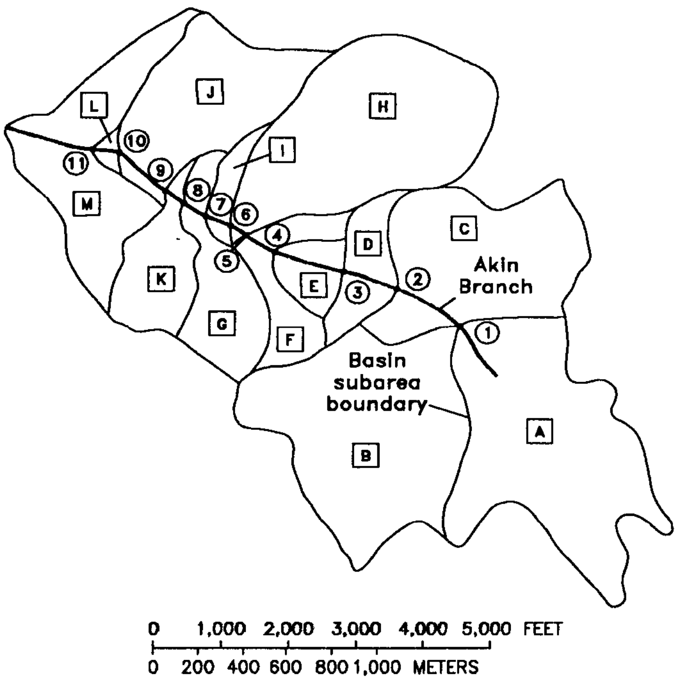
Structure number	Structure name	Stream stationing	Structure description
1	James Campbell Boulevard culvert.	0+59 - 2+00	Two-barrel concrete box culvert. Average barrel inlet, 8 feet x 6 feet. Length, 141 feet.
2	Store entrance culvert	9+10 - 9+50	Two-barrel concrete box culvert. Average barrel inlet, 8 feet x 6.6 feet. Length, 40 feet.
3	Bank entrance culvert	13+37 - 13+63	Three-barrel concrete box culvert. Average barrel inlet, 8.5 feet x 5.5 feet. Length, 26 feet.
4	Wedgewood Drive bridge	15+85 - 16+07	Single span concrete bridge. Inlet, 15.5 feet x 4 feet. Length, 22 feet.
5	Alpine Drive bridge	20+00 - 20+22	Single span concrete bridge. Inlet, 15 feet x 5 feet. Length, 22 feet.
6	Store entrance culvert	22+50 - 22+84	Two-barrel concrete box culvert. Barrel inlet, 8 feet x 8.2 feet. Length, 34 feet.
7	Shady Brook Lane culvert	25+50 - 26+21	One-barrel concrete box culvert. Barrel inlet, 14 feet x 5 feet. Length, 71 feet.
8	Mall entrance culvert	30+23 - 32+18	One-barrel concrete box culvert. Barrel inlet, 14 feet x 4.4 feet. Length, 195 feet.
9	Mall parking lot culvert	35+80 - 42+20	One-barrel concrete box culvert. Barrel inlet, 14 feet x 5.1 feet. Length, 640 feet.
10	Brookmeade Road culvert	43+37 - 44+22	One-barrel concrete box culvert. Barrel inlet, 10 feet x 5.9 feet. Length, 85 feet.
11	Denise Drive culvert	55+10 - 55+44	One-barrel concrete box culvert. Barrel inlet, 12 feet x 6.8 feet. Length, 34 feet.
12	Highland Avenue culvert	69+44 - 69+84	One-barrel corrugated metal pipe. Average pipe diameter, 3.5 feet. Length, 40 feet.
13	Lumberyard culvert	69+90 - 71+70	One-barrel corrugated metal pipe. Average pipe diameter, 4.5 feet. Length, 180 feet.

subarea were calculated using the equations developed by Robbins (1984). These values were input to the WSPRO model for the calculation of the water-surface profiles.

Flood Profiles

The hydraulic model was calibrated for existing conditions based on high-water marks that were obtained shortly after the flood of February 3, 1990 (table 2). The recurrence interval of this flood was approximately 5 years (fig. 4). Highwater marks shown for the February 3, 1990 flood in the vicinity of Denise Drive (stream station 55+00) are higher than the completed profiles because a new culvert was constructed at that location between February 3, 1990, and the time the profiles were computed.

AKIN BRANCH WATERSHED



EXPLANATION

(1) NODE AND NUMBER

[B] BASIN SUBAREA DESIGNATION

BASIN SUBAREA FLOOD DISCHARGES

Basin subarea	Area, in square miles	Percent of total flow	Discharge, in cubic feet per second, for indicated recurrence interval, in years		
			Q_5	Q_{10}	Q_{25}
A	0.305	18.1	140	175	210
B	.292	17.3	140	165	205
C	.207	12.2	95	115	145
D	.050	3.0	25	30	35
E	.034	2.0	15	20	25
F	.058	3.4	25	35	40
G	.084	5.0	40	50	60
H	.280	16.6	130	160	195
I	.020	1.2	10	10	15
J	.161	9.5	75	90	110
K	.074	4.4	35	40	50
L	.006	.4	5	5	5
M	.119	7.0	55	65	85

BASIN FLOOD DISCHARGES

Node number	Stream stationing	Discharge, in cubic feet per second, for indicated recurrence interval, in years		
		Q_5	Q_{10}	Q_{25}
0 - 1	72+75 - 63+58	140	175	210
1 - 2	63+58 - 54+90	280	340	415
2 - 3	54+90 - 43+00	400	485	595
3 - 4	43+00 - 35+12	400	485	595
4 - 5	35+12 - 29+82	415	505	620
5 - 6	29+82 - 24+74	440	540	660
6 - 7	24+74 - 22+22	580	710	870
7 - 8	22+22 - 18+58	620	760	930
8 - 9	18+58 - 15+56	655	800	980
9 - 10	15+56 - 4+55	655	800	980
10 - 11	4+55 - 0+00	735	895	1,100

URBAN RUNOFF EQUATIONS (Robbins, 1984)

$Q_5 = 5.55\,(A)^{0.75}\,(IA)^{0.44}\,(P2\_24)^{2.53}$

$Q_{10} = 11.8\,(A)^{0.75}\,(IA)^{0.43}\,(P2\_24)^{2.12}$

$Q_{25} = 21.9\,(A)^{0.75}\,(IA)^{0.39}\,(P2\_24)^{1.89}$

P2_24 = 3.6 inches

Where

- Q_n is the estimated flood discharge, in cubic feet per second, for the indicated recurrence interval, in years;
- A is the area of the watershed, in square miles;
- IA is the percentage of the drainage area that is impervious to infiltration of rainfall; and
- P2_24 is the 2-year 24-hour rainfall amount, in inches.

Average basin impervious area is 20 percent
Total basin area is 1.69 square miles

Total basin flows

Q_5 = 5.55 x 1.483 x 3.74 x 25.6 =790 cubic feet per second

Q_{10} = 11.8 x 1.483 x 3.63 x 15.1 =960 cubic feet per second

Q_{25} = 21.9 x 1.483 x 3.22 x 11.3 =1,180 cubic feet per second

Figure 3. Akin Branch flood discharges for selected recurrence intervals.

Using the calibrated model for the February 3 flood discharge, flood profiles were computed for existing channel conditions for 5-, 10-, and 25-year recurrence intervals (fig. 4a-4g). Selected output from the hydraulic model has been tabulated to aid in interpretation of results (table 3). The computed flood profiles indicate road overtopping of as much as 2.5 feet at Wedgewood Drive and as much as 1.5 feet at Alpine Drive for the 25-year flood. The profiles also indicate that backwater (hydraulic head buildup) of about 1.4 feet occurs at the upstream side of Alpine Drive. These adverse hydraulic conditions are attributed to undersized structures and flood-plain development.

Simulation of Effects of Alternative Drainage Structures

The calibrated hydraulic model was used to simulate the flood profiles at Akin Branch that would result from possible alternative designs for selected drainage structures. Data on existing structure sizes are listed in table 1, and the alternative drainage improvement designs evaluated using the model are described below for model simulations 1 through 3.

Simulation 1: A three-barrel concrete box culvert with a total barrel width of 24 feet, barrel height of 7 feet, and culvert length of 30 feet was simulated at Wedgewood and Alpine Drives.

Table 2. Akin Branch high-water mark elevations for the February 3, 1990 flood

[High-water mark elevations, in feet. Add 564.29 to convert elevation to sea level. Stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	High-water mark elevation	Stream stationing	High-water mark elevation	Stream stationing	High-water mark elevation
0+35	43.9	18+58	59.9	43+30	80.9
2+45	46.3	20+00	60.4	44+50	83.6
3+06	47.6	20+75	61.9	44+90	83.6
4+40	51.2	22+30	63.0	52+80	91.3
5+00	52.6	23+28	64.7	55+10	92.0
5+70	53.0	23+75	65.1	56+30	94.1
6+50	53.8	24+74	65.2	58+35	94.4
7+10	54.5	25+50	64.7	60+50	94.5
7+25	54.7	26+36	66.5	65+60	98.6
9+10	56.7	30+23	71.8	67+00	100.5
11+00	57.2	32+38	73.5	67+40	101.3
13+37	58.7	33+25	73.7	71+80	107.9
14+60	59.1	34+10	73.7	72+75	108.7
15+85	59.1	35+27	73.9	73+20	108.8
16+20	59.7	42+55	81.3		

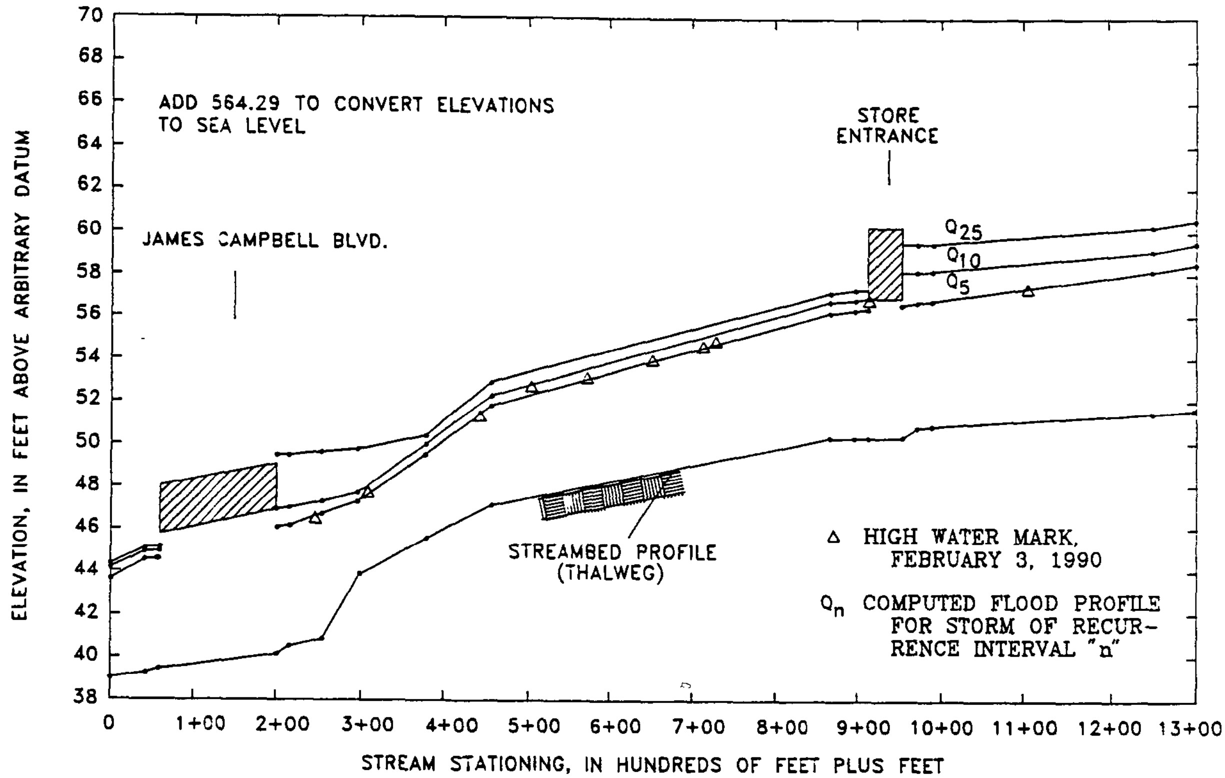


Figure 4a. Computed flood profiles, existing conditions, with February 3, 1990, high-water marks for Akin Branch.

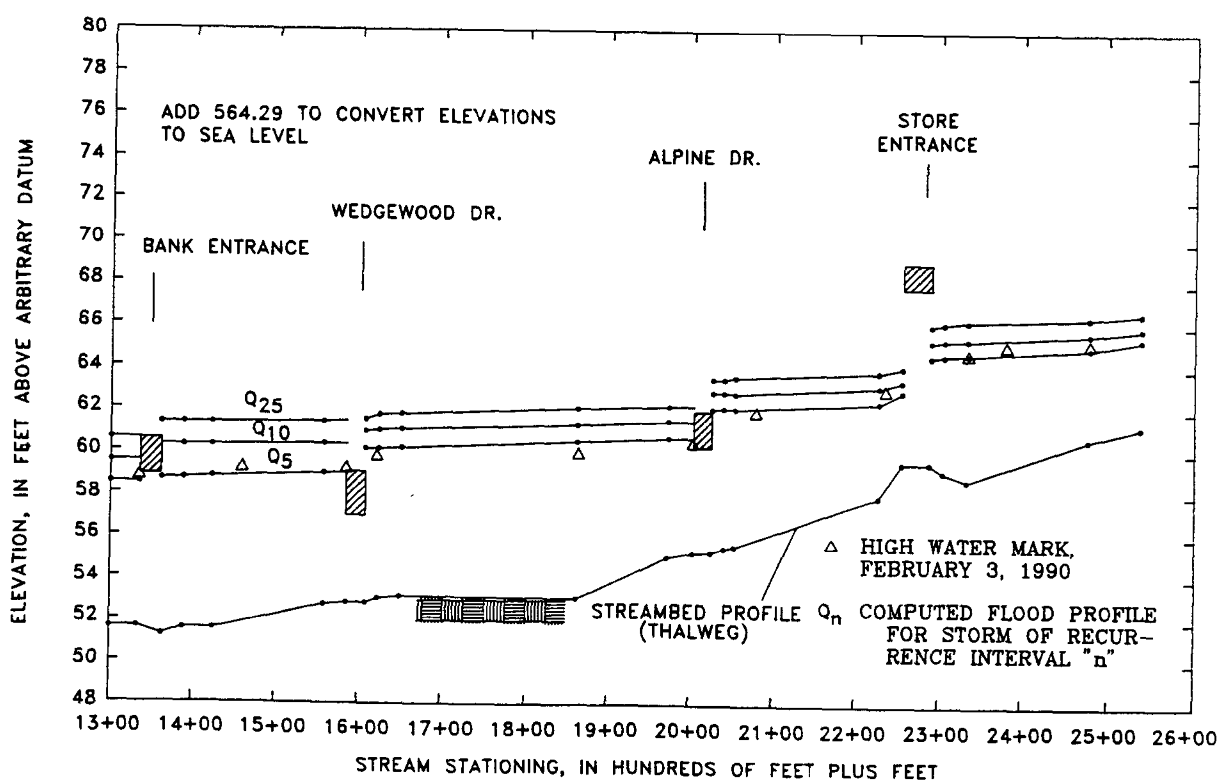


Figure 4b. Computed flood profiles, existing conditions, with February 3, 1990, high-water marks for Akin Branch--Continued.

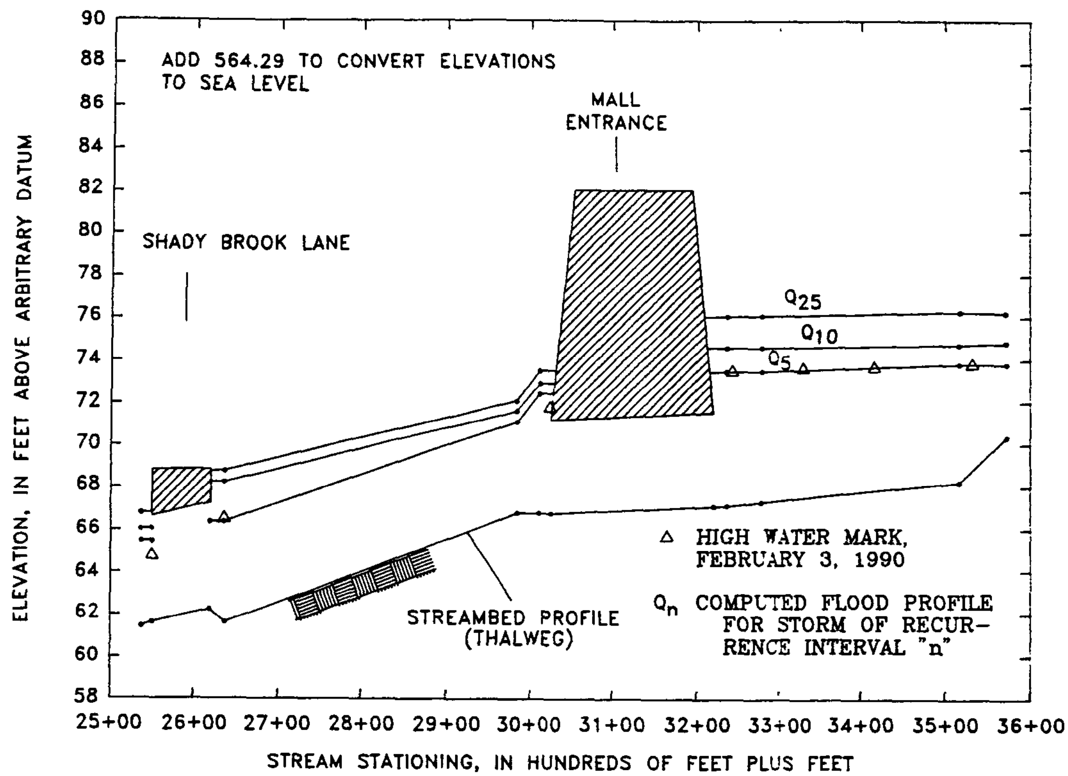


Figure 4c. Computed flood profiles, existing conditions, with February 3, 1990, high-water marks for Akin Branch--Continued.

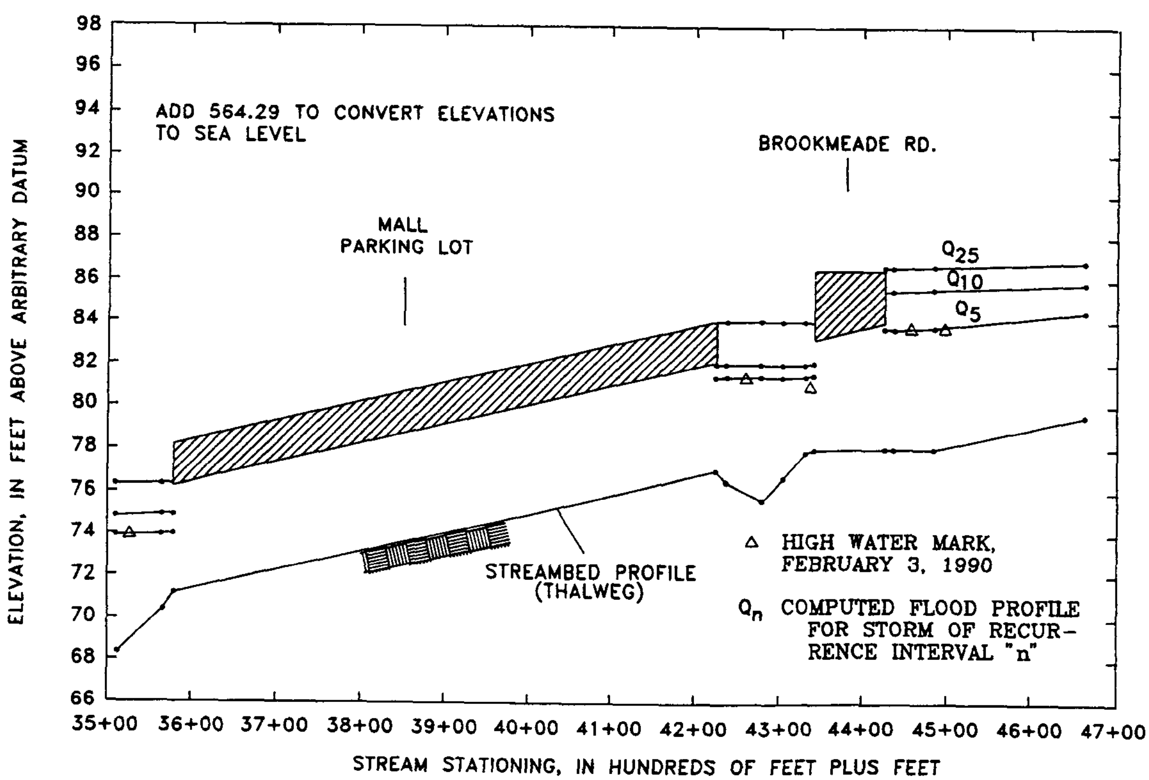


Figure 4d. Computed flood profiles, existing conditions, with February 3, 1990, high-water marks for Akin Branch--Continued.

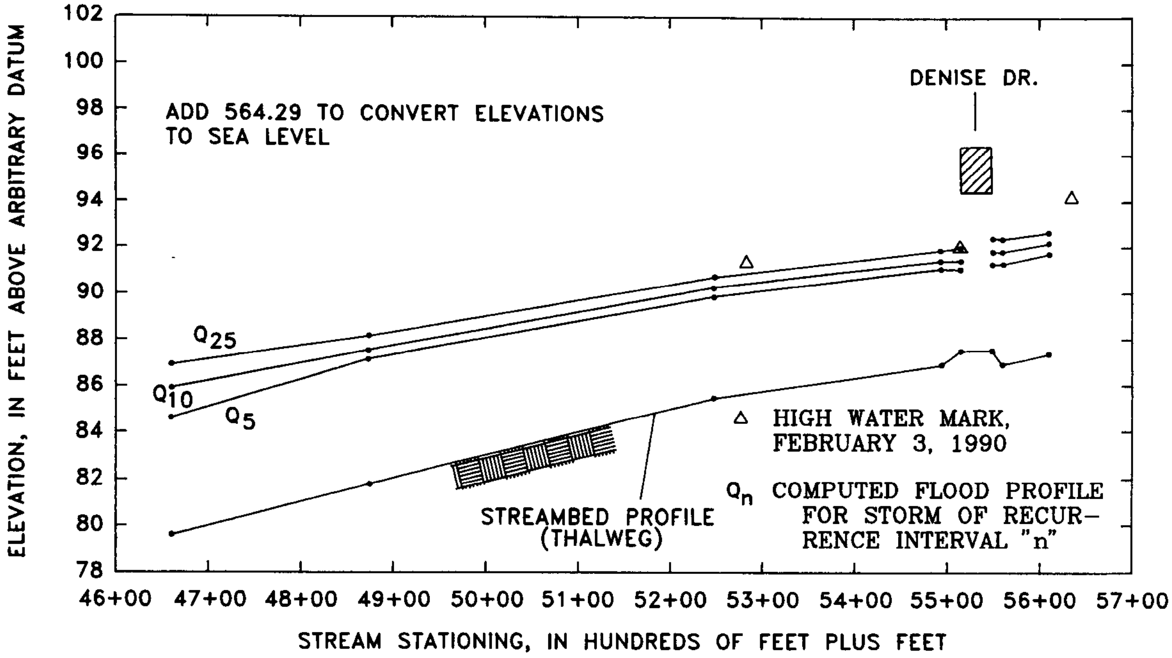


Figure 4e. Computed flood profiles, existing conditions, with February 3, 1990, high-water marks for Akin Branch--Continued.

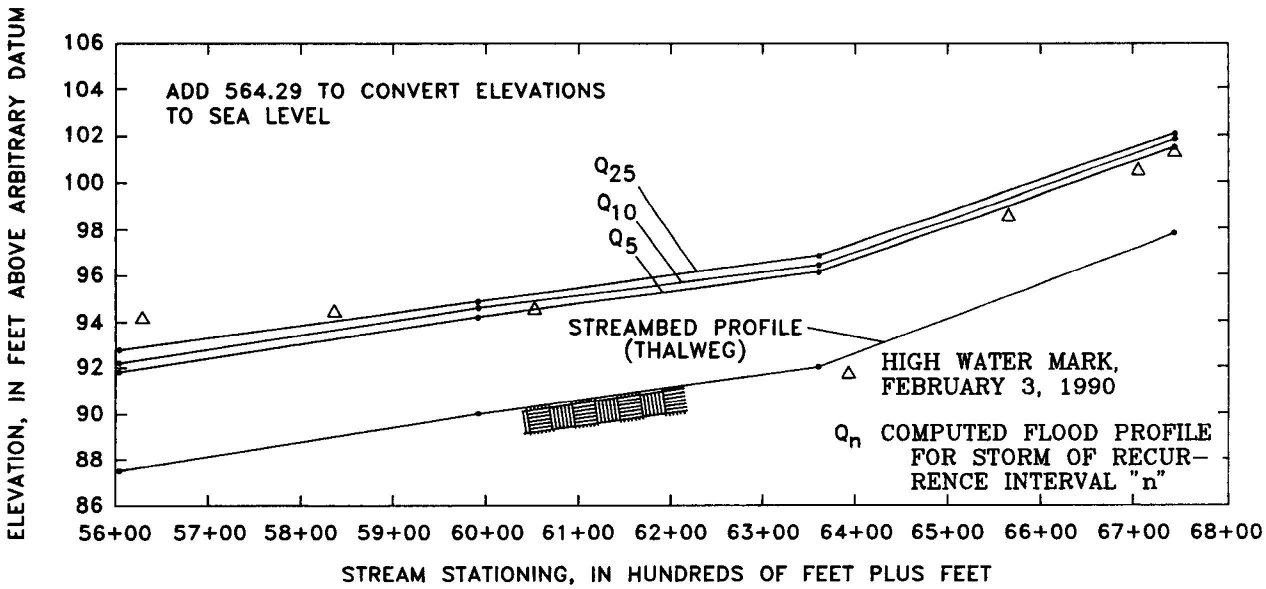


Figure 4f. Computed flood profiles, existing conditions, with February 3, 1990, high-water marks for Akin Branch--Continued.

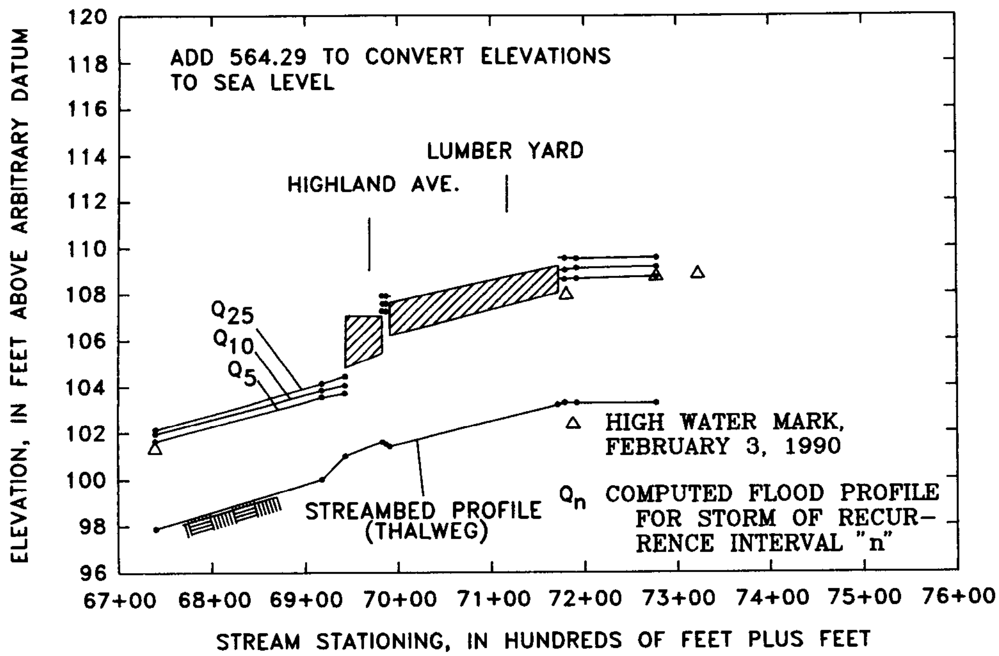


Figure 4g. Computed flood profiles, existing conditions, with February 3, 1990, high-water marks for Akin Branch--Continued.

Simulation 2: A three-barrel concrete box culvert with a total barrel width of 21 feet, barrel height of 6.5 feet, and length of 30 feet was simulated at Wedgewood Drive. A three-barrel concrete box culvert with a total barrel width of 22.5 feet, barrel height of 6.5 feet, and length of 30 feet was simulated at Alpine Drive.

Simulation 3: A three-barrel concrete box culvert with a total barrel width of 24 feet, barrel height of 6 feet, and culvert length of 30 feet was simulated at Wedgewood Drive with maximum channel excavation of 0.8 foot between stations 14+25 and 16+48. A three-barrel concrete box culvert with a total barrel width 24 feet, barrel height of 6 feet, and culvert length of 30 feet was simulated at Alpine Drive.

The simulated flood profiles for the three conditions (fig. 5, 6, and 7) indicate that during the 25-year flood: Drainage improvements modeled in simulation 1 would result in an increase of 0.3 foot in the water-surface elevation upstream from Wedgewood Drive and a decrease of 0.7 foot in the water-surface elevation upstream from Alpine Drive (table 4, fig. 5). No culvert overtopping would occur. Drainage improvements modeled in simulation 2 would result in an increase of 0.6 foot in the water-surface elevation upstream from Wedgewood Drive and a decrease of 0.2 foot in the water-surface elevation upstream from Alpine Drive (table 5, fig. 6). About one-half foot of culvert overtopping would occur at Wedgewood Drive. Drainage improvements modeled in simulation 3 would result in a decrease of 0.2 foot in the water-surface elevation upstream from Wedgewood Drive and a decrease of 0.9 foot in the water-surface elevation upstream from Alpine Drive (table 6, fig. 7). Two feet of culvert overtopping would occur at Wedgewood Drive.

For existing conditions, culvert overtopping of approximately 2.5 feet at Wedgewood Drive and 1.5 feet at Alpine Drive can be expected during the 25-year flood. These analyses indicate that culvert overtopping at Wedgewood Drive is necessary to reduce upstream water-surface elevations for existing downstream conditions.

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
0+00	43.6	44.1	44.3	735	895	950	8.5	8.2	8.4	87	109	114	39.0	41.5	--	--	
0+43	44.5	44.9	45.0	735	895	950	6.7	7.3	7.4	110	123	128	39.2	42.0	--	--	James Campbell Blvd culvert tailwater.
0+59	44.5	44.9	45.0	735	895	950	10.9	11.2	11.7	67	80	81	39.4	--	45.7	48.0	James Campbell Blvd culvert outlet.
2+00	46.0	46.9	46.9	735	895	950	9.0	9.2	9.8	82	97	97	40.1	--	46.9	49.0	James Campbell Blvd culvert inlet.
2+00	--	--	49.4	--	--	150	--	--	8.8	--	--	17	--	--	--	49.0	James Campbell Blvd road deck.
2+16	46.1	46.9	49.4	735	895	1100	8.3	8.5	6.1	89	106	180	40.5	46.5	--	--	James Campbell Blvd culvert headwater.
2+52	46.6	47.2	49.5	735	895	1100	5.4	5.6	4.6	135	160	242	40.8	47.0	--	--	
2+96	47.2	47.6	49.7	735	895	1100	8.8	9.4	6.3	83	96	176	43.8	48.0	--	--	
3+76	49.4	49.9	50.3	735	895	1100	9.3	9.8	10.4	79	91	106	45.5	51.0	--	--	
4+55	51.7	52.3	52.8	655	800	980	9.9	10.2	10.1	66	79	97	47.1	52.0	--	--	

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
8+65	56.1	56.6	57.1	655	800	980	6.7	7.3	8.1	98	110	121	50.3	58.0	--	--	
8+93	56.3	56.8	57.2	655	800	980	7.0	7.6	8.4	94	105	116	50.3	58.0	--	--	Store culvert tailwater.
9+10	56.4	56.9	56.9	655	800	980	6.3	7..5	9.2	104	107	107	50.3	--	56.9	60.2	Store culvert outlet.
9+50	56.5	56.9	56.9	655	800	980	6.3	7.5	9.2	104	107	107	50.3	--	56.9	60.2	Store culvert inlet.
9+50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60.2	Store culvert road deck.
9+67	56.6	58.1	59.4	655	800	980	6.2	5.6	5.4	105	143	183	50.8	59.0	--	--	Store culvert headwater.
9+85	56.6	58.1	59.4	655	800	980	6.5	5.8	5.7	101	137	173	50.9	59.0	--	--	
12+50	58.1	59.1	60.2	655	800	980	5.8	5.8	6.0	114	137	165	51.5	60.0	--	--	
13+00	58.4	59.4	60.5	655	800	980	4.6	4.5	4.3	143	177	226	51.6	60.0	--	--	Bank culvert tailwater.
13+37	58.4	58.8	58.8	655	800	810	4.7	5.4	5.5	140	147	147	51.6	--	58.8	60.5	Bank culvert outlet.
13+63	58.6	58.8	58.8	655	800	810	4.9	5.7	5.8	135	140	140	51.2	--	58.8	60.5	Bank culvert inlet.
13+63	--	--	61.3	--	--	170	--	--	3.5	--	--	49	--	--	--	60.5	Bank culvert road deck.
13+90	58.6	60.2	61.3	655	800	980	3.5	2.8	2.7	187	284	364	51.5	56.0	--	--	Bank culvert headwater.
14+25	58.7	60.2	61.3	655	800	980	3.4	2.8	2.7	191	288	363	51.5	56.0	--	--	

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
15+56	58.9	60.3	61.4	655	800	980	3.7	3.2	3.2	178	252	305	52.7	56.0	--	--	Wedgewood Drive bridge tailwater.
15+85	56.9	56.9	56.9	480	380	310	7.5	5.9	4.8	65	65	65	52.8	--	56.9	59.0	Wedgewood Drive bridge outlet.
16+07	56.9	56.9	56.9	480	380	310	7.5	5.9	4.8	65	65	65	52.8	--	56.9	59.0	Wedgewood Drive bridge inlet.
16+07	60.1	60.9	61.5	175	420	670	4.1	5.3	6.2	43	79	108	--	--	--	59.0	Wedgewood Drive road deck.
16+23	60.1	61.0	61.7	655	800	980	3.1	3.1	3.4	214	257	292	53.0	56.0	--	--	Wedgewood Drive bridge headwater.
16+48	60.2	61.1	61.8	655	800	980	3.0	3.1	3.3	219	262	297	53.1	56.0	--	--	
16+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.5	Floor 61.6	House on right bank.
18+58	60.5	61.3	62.1	620	760	930	4.1	4.0	4.2	151	190	224	53.1	57.0	--	--	
18+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.3	Floor 65.7	House on right bank.

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
19+70	60.7	61.5	62.2	620	760	930	4.8	4.6	4.8	128	164	195	55.0	58.0	--	--	Alpine Drive bridge tailwater.
20+00	60.3	60.3	60.3	580	590	590	7.7	7.8	7.8	75	75	75	55.3	--	60.3	62.0	Alpine Drive bridge outlet.
20+22	60.3	60.3	60.3	580	590	590	7.7	7.8	7.8	75	75	75	55.3	--	60.3	62.0	Alpine Drive bridge inlet.
20+22	62.1	62.9	63.5	40	170	340	5.3	4.2	4.9	8	40	69	--	--	--	62.0	Alpine Drive road deck.
20+37	62.1	62.9	63.5	620	760	930	3.9	3.9	4.2	160	195	223	55.5	60.5	--	--	Alpine Drive bridge headwater.
20+50	62.1	62.9	63.6	620	760	930	3.9	4.0	4.2	157	192	220	55.6	60.5	--	--	
20+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 63.4	Floor 67.1	House on right bank.
22+22	62.5	63.2	63.9	580	710	870	4.5	4.3	4.5	130	164	194	58.0	63.0	--	--	Store culvert tailwater.
22+50	63.0	63.5	64.1	580	710	870	10.5	11.3	12.0	55	63	72	59.6	--	67.8	69.0	Store culvert outlet.

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
22+84	64.6	65.3	66.1	580	710	870	7.3	7.8	8.4	80	91	104	59.6	--	67.8	69.0	Store culvert inlet.
22+84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	69.0	Store culvert road deck.
23+00	64.7	65.4	66.2	580	710	870	4.2	4.2	4.2	139	168	205	59.2	65.0	--	--	Store culvert headwater.
23+28	64.7	65.4	66.3	580	710	870	4.0	4.1	4.1	146	175	212	58.8	65.0	--	--	
24+74	65.1	65.7	66.5	440	540	660	5.6	5.3	4.8	79	102	137	60.8	65.0	--	--	
25+36	65.4	66.0	66.7	440	540	660	5.5	5.4	5.1	81	100	130	61.4	65.0	--	--	Shady Brook Lane culvert tailwater.
25+50	65.4	66.0	66.6	440	540	660	8.3	8.7	9.4	53	62	70	61.6	--	66.6	68.8	Shady Brook Lane culvert outlet.
26+21	66.3	67.2	67.2	440	540	660	7.7	7.7	9.4	57	70	70	62.2	--	67.2	68.8	Shady Brook Lane culvert inlet.
26+21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	68.8	Shady Brook Lane road deck.

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
26+36	66.3	68.2	68.7	440	540	660	4.7	3.3	3.6	93	165	186	61.6	69.0	--	--	Shady Brook Lane culvert headwater.
29+82	71.1	71.6	72.1	415	505	620	9.5	9.9	10.2	43	51	61	66.8	73.0	--	--	
30+09	72.4	72.9	73.5	415	505	620	4.6	4.9	5.2	91	104	119	66.8	74.0	--	--	Mall entrance culvert tailwater.
30+23	71.2	71.2	71.2	415	505	620	6.7	8.1	10.0	62	62	62	66.8	--	71.2	82.0	Mall entrance culvert outlet.
32+18	71.6	71.6	71.6	415	505	620	6.7	8.1	10.0	62	62	62	67.2	--	71.6	82.0	Mall entrance culvert inlet.
32+18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	82.0	Mall entrance road deck.
32+32	73.5	74.6	76.1	415	505	620	3.0	2.9	2.6	140	177	238	67.2	77.0	--	--	Mall entrance culvert headwater.
32+74	73.5	74.6	76.1	415	505	620	3.0	2.9	2.7	137	173	232	67.4	78.0	--	--	
35+12	73.9	74.8	76.3	400	485	595	4.1	3.8	3.2	98	129	184	68.3	78.0	--	--	
35+66	73.9	74.9	76.3	400	485	595	6.0	5.4	4.5	67	91	132	70.4	78.0	--	--	Mall parking lot culvert tailwater.

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
35+80	74.0	74.9	76.2	400	485	595	9.8	9.2	8.4	41	53	71	71.1	--	76.2	78.1	Mall parking lot culvert outlet.
42+20	81.4	82.0	82.1	400	485	595	6.5	6.9	8.4	62	70	71	77.0	--	82.1	84.0	Mall parking lot culvert inlet.
42+20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	84.0	Mall parking lot culvert road deck.
42+34	81.4	82.0	84.0	400	485	595	3.1	3.1	2.5	131	155	240	76.5	84.0	--	--	Mall parking lot culvert headwater.
42+75	81.4	82.0	84.0	400	485	595	3.0	3.1	2.6	133	155	231	75.7	84.0	--	--	
43+00	81.4	82.0	84.0	400	485	595	4.5	4.6	3.5	89	106	170	76.7	84.0	--	--	
43+27	81.4	82.0	84.0	400	485	595	7.1	6.9	5.0	56	70	120	77.9	84.0	--	--	Brookmeade Road culvert tailwater.
43+37	81.5	82.1	83.2	400	485	560	11.8	12.1	11.0	34	40	51	78.1	--	83.2	86.5	Brookmeade Road culvert outlet.
44+22	83.7	84.0	84.0	400	485	560	7.1	8.2	9.5	56	59	59	78.1	--	84.0	86.5	Brookmeade Road culvert inlet.
44+22	--	--	86.6	--	--	35	--	--	5.0	--	--	7	--	--	--	86.5	Brookmead Road road deck.

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
44+32	83.7	85.5	86.6	400	485	595	4.5	3.6	3.6	89	135	165	78.1	85.0	--	--	Brookmeade Road culvert headwater.
44+80	83.8	85.6	86.7	400	485	595	4.6	3.7	3.7	87	131	161	78.1	85.0	--	--	
46+60	84.5	85.9	86.9	400	485	595	8.1	6.7	6.2	49	72	96	79.6	86.0	--	--	
48+73	87.1	87	88.1	400	485	595	6.4	6.9	7.0	62	70	85	81.8	86.0	--	--	
52+45	89.9	90.3	90.7	400	485	595	5.7	5.7	6.0	71	85	99	85.5	89.0	--	--	
54+90	91.1	91.5	92.0	280	340	415	3.2	3.4	3.6	88	100	115	87.0	90.0	--	--	Denise Drive culvert tailwater.
55+10	91.1	91.5	92.0	280	340	415	6.7	7.2	7.8	42	47	53	87.6	--	94.4	96.4	Denise Drive culvert outlet.
55+44	91.3	91.8	92.4	280	340	415	6.4	6.8	7.2	44	50	58	87.6	--	94.4	96.4	Denise Drive culvert inlet.
55+44	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	96.4	Denise Drive road deck.
55+56	91.3	91.8	92.4	280	340	415	5.6	5.0	4.6	50	68	90	87.0	90.0	--	--	Denise Drive culvert headwater.
56+05	91.8	92.2	92.7	280	340	415	4.1	4.2	4.2	68	82	100	87.5	90.0	--	--	

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
59+90	94.2	94.6	94.8	280	340	415	4.4	4.7	5.0	63	72	82	90.0	92.0	--	--	
63+58	96.2	96.5	96.9	140	175	210	2.6	2.8	2.9	54	63	73	92.1	94.0	--	--	
67+40	101.6	101.9	102.1	140	175	210	5.7	6.0	6.1	25	29	34	97.9	100.0	--	--	
69+18	103.5	103.8	104.1	140	175	210	3.9	4.2	4.5	36	42	47	100.0	102.5	--	--	Highland Avenue culvert tailwater.
69+44	103.7	104.0	104.4	130	145	150	10.0	10.0	9.4	13	15	16	101.0	--	104.8	107.0	Highland Avenue culvert outlet.
69+84	105.4	105.4	105.4	130	145	150	7.6	8.5	8.8	17	17	17	101.6	--	105.4	107.0	Highland Avenue culvert inlet.
69+84	107.2	107.6	107.9	10	30	60	2.5	3.1	3.8	4	10	16	--	--	--	107.0	Highland Avenue road deck.
69+87	107.2	107.6	107.9	140	175	210	2.1	2.4	2.7	66	73	79	101.5	--	--	--	Highland Avenue culvert headwater.
69+87	107.2	107.6	107.9	140	175	210	2.1	2.4	2.7	66	73	79	101.5	--	--	--	Lumber yard culvert tailwater.
69+90	106.2	106.2	106.2	140	175	195	5.4	6.7	7.5	26	26	26	101.4	--	106.2	107.6	Lumber yard culvert outlet.

Table 3. Selected data from hydraulic analysis of Akin Branch, existing conditions--Continued

[Add 564.29 to convert elevations to sea level; yr, year; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
71+70	108.0	108.0	108.0	140	175	195	5.4	6.7	7.5	26	26	26	103.2	--	108.0	109.2	Lumber yard culvert inlet.
71+70	--	--	109.5	--	--	15	--	--	3.1	--	--	5	--	--	--	109.2	Lumber yard road deck.
71+76	108.6	109.0	109.5	140	175	210	2.4	2.6	2.8	59	67	75	103.3	106.0	--	--	Lumber yard culvert headwater.
71+90	108.6	109.1	109.5	140	175	210	2.4	2.6	2.8	58	67	74	103.3	106.0	--	--	
72+75	108.7	109.2	109.6	140	175	210	2.6	2.8	2.9	55	64	71	103.3	107.0	--	--	

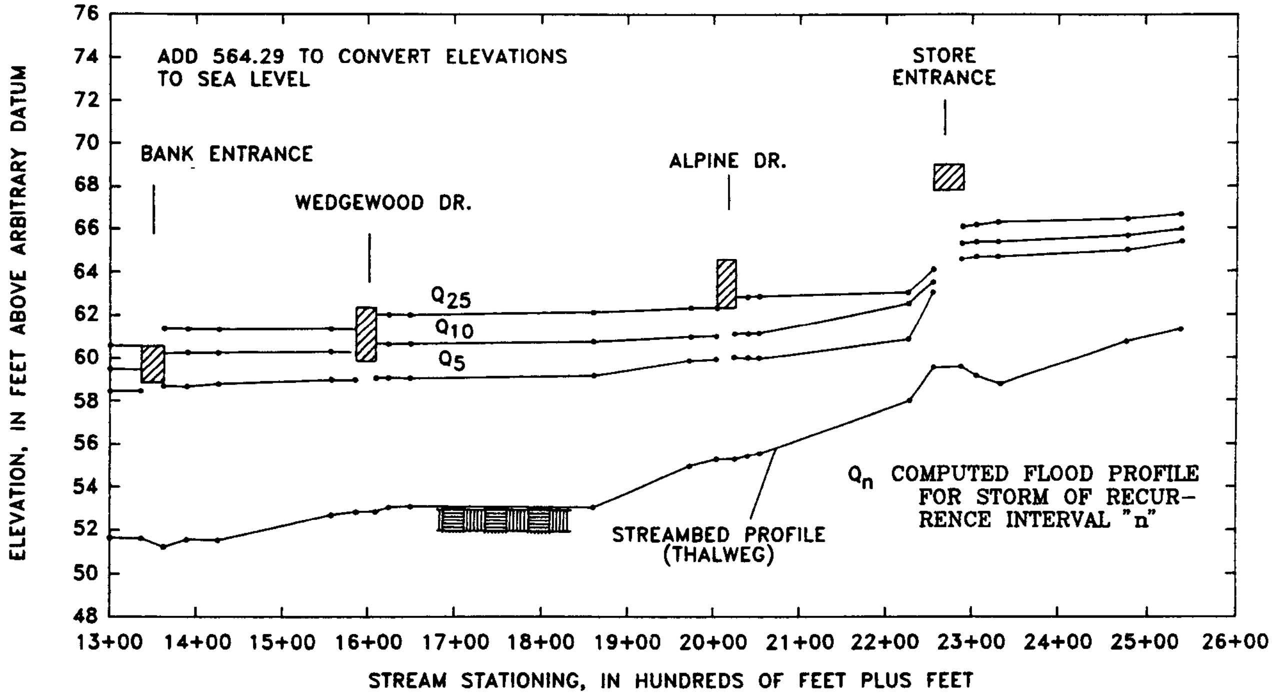


Figure 5. Computed flood profiles for Akin Branch, simulation 1.

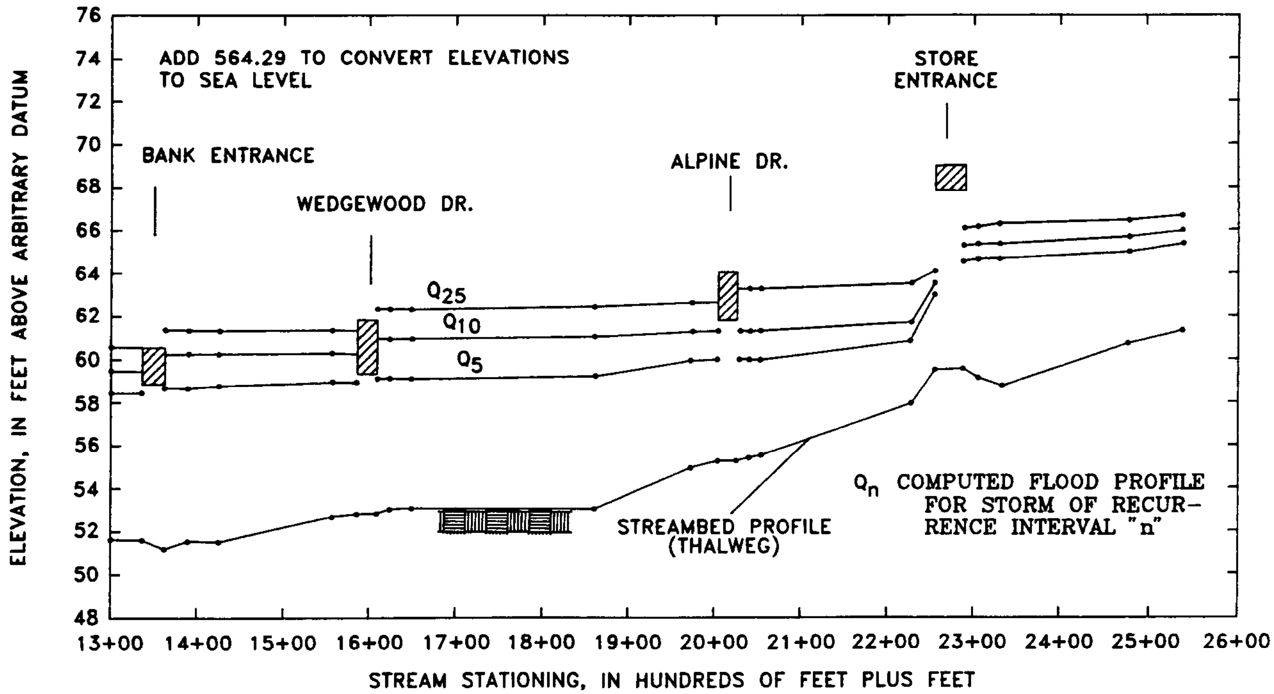


Figure 6. Computed flood profiles for Akin Branch, simulation 2.

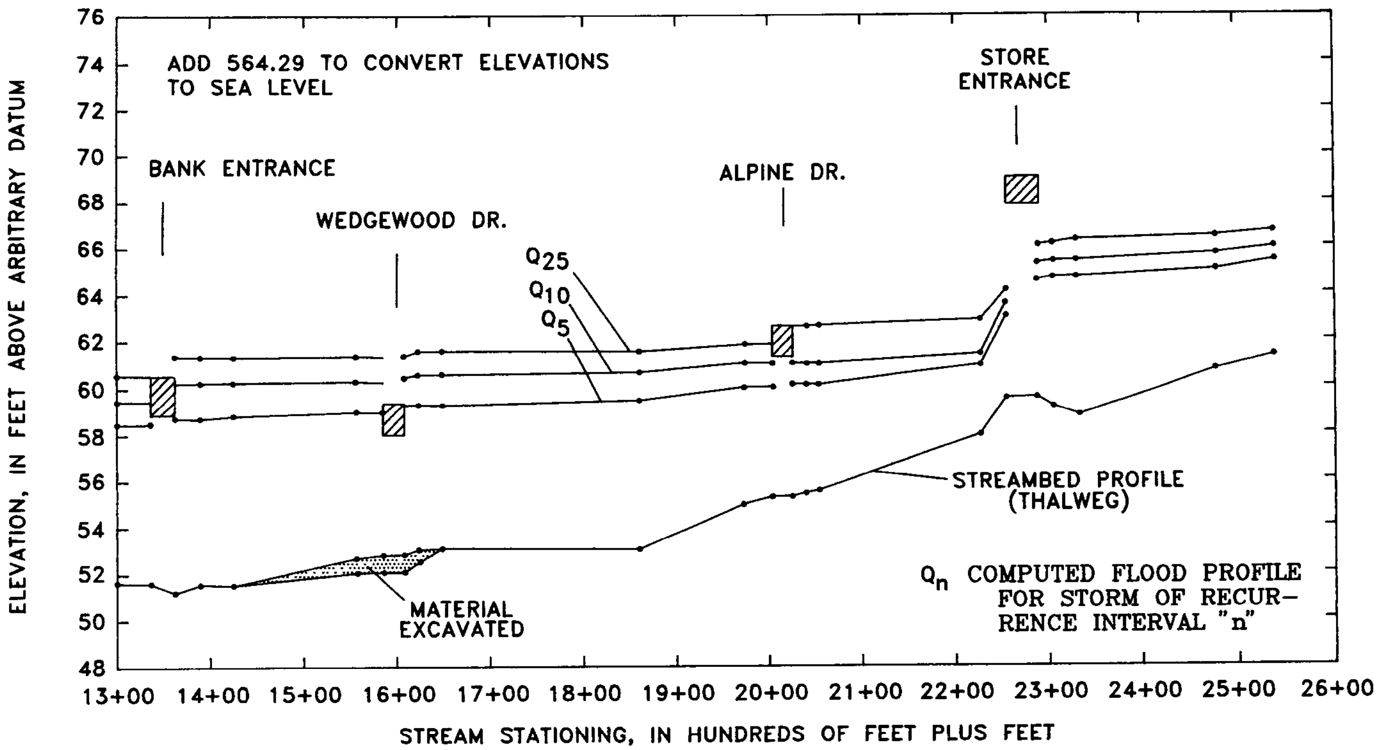


Figure 7. Computed flood profiles for Akin Branch, simulation 3.

Cayce Valley Branch

Cayce Valley Branch drains a small urban watershed with a contributing drainage area of 1.04 mi^2. At present, residential and commercial development account for about 5 percent of the basin. However, the potential for continued development could result in 10 percent of the contributing drainage area becoming impervious to infiltration of rainfall in the future. This value of imperviousness was used to estimate flood discharges for future developed conditions.

The study reach (fig. 8) begins at a point approximately 100 feet downstream from Whitney Drive (structure 1), and extends upstream approximately 5,000 feet (measured along the centerline of the stream) to a point just upstream of the culvert under Jewell Drive (structure 11) (table 7). The study reach contains a total of 11 culverts and bridges.

Flood Discharges

Flood discharges for Cayce Valley Branch were computed by assigning a percentage of the total basin flood discharge to each basin subarea based on the percentage of the watershed occupied by the subarea (fig. 9). The watershed was subdivided on the basis of topography and the location of tributaries draining into the creek. Flood discharges for the 5-, 10-, and 25-year recurrence intervals for each basin subarea were calculated using the equations developed by Robbins (1984). These values were input to the WSPRO model for the calculation of water-surface profiles.

Table 4. Selected data from hydraulic analysis of Akin Branch, simulation 1

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
14+25	58.7	60.2	61.3	655	800	980	3.5	2.8	2.7	189	288	360	51.5	56.0	--	--	
15+56	58.9	60.2	61.3	655	800	980	3.0	2.8	2.8	220	288	346	52.7	56.0	--	--	Wedgewood Drive culvert tailwater.
15+85	58.9	59.8	59.8	655	800	980	4.5	4.8	5.8	146	168	168	52.8	--	59.8	62.3	Wedgewood Drive culvert outlet.
16+07	59.0	59.8	59.8	655	800	980	4.4	4.8	2.8	149	168	168	52.8	--	59.8	62.3	Wedgewood Drive culvert inlet.
16+07	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	62.3	Wedgewood Drive road deck.
16+23	59.0	60.6	62.0	655	800	980	3.1	2.7	2.7	214	295	362	53.0	56.0	--	--	Wedgewood Drive culvert headwater.
16+48	59.0	60.6	62.0	655	800	980	3.1	2.7	2.7	215	295	362	53.1	56.0	--	--	
16+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.5	Floor 61.6	House on right bank.
18+58	59.1	60.7	62.1	620	760	930	6.9	4.7	4.1	90	161	225	53.1	57.0	--	--	
18+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.3	Floor 65.7	House on right bank .

Table 4. Selected data from hydraulic analysis of Akin Branch, simulation 1--Continued

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
19+70	59.9	61.0	62.3	620	760	930	4.0	3.8	3.6	154	199	255	55.0	58.0	--	--	Alpine Drive culvert tailwater.
20+00	59.9	61.0	62.3	620	760	930	5.6	5.5	5.5	110	137	168	55.3	--	62.3	64.5	Alpine Drive culvert outlet.
20+22	60.0	61.1	62.3	620	760	930	5.5	5.4	5.5	113	140	168	55.3	--	62.3	64.5	Alpine Drive culvert inlet.
20+22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	64.5	Alpine Drive road deck.
20+37	60.0	61.1	62.8	620	760	930	4.9	4.6	3.9	126	164	238	55.5	60.5	--	--	Alpine Drive culvert headwater.
20+50	60.0	61.1	62.8	620	760	930	5.3	5.0	4.3	118	152	216	55.6	60.5	--	--	
20+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 63.4	Floor 67.1	House on right bank.
22+22	60.9	61.5	63.0	580	710	870	8.3	7.8	5.7	70	91	152	58.0	63.0	--	--	Store culvert tailwater.
22+50	63.0	63.5	64.1	580	710	870	10.5	11.3	12.1	55	63	72	59.6	--	67.8	69.0	Store culvert outlet.
22+84	64.6	65.3	66.1	580	710	870	7.3	7.8	8.4	80	91	104	59.6	--	67.8	69.0	Store culvert inlet.

Table 4. Selected data from hydraulic analysis of Akin Branch, simulation 1--Continued

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
22+84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	69.0	Store culvert road deck.
23+00	64.7	65.4	66.2	580	710	870	4.2	4.2	4.2	139	168	205	59.2	65.0	--	--	Store culvert headwater.

Table 5. Selected data from hydraulic analysis of Akin Branch, simulation 2

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
14+25	58.7	60.2	61.3	655	800	980	3.5	2.8	2.7	189	288	360	51.5	56.0	--	--	
15+56	58.9	60.2	61.3	655	800	980	3.0	2.8	2.8	220	288	346	52.7	56.0	--	--	Wedgewood Drive culvert tailwater.
15+85	58.9	59.3	59.3	655	800	910	5.1	5.9	6.7	128	136	136	52.8	--	59.3	61.8	Wedgewood Drive culvert outlet.
16+07	59.0	59.3	59.3	655	800	910	5.0	5.9	6.7	130	136	136	52.8	--	59.3	61.8	Wedgewood Drive culvert inlet.
16+07	--	--	62.3	--	--	70	--	--	3,0	--	--	23	--	--	--	61.8	Wedgewood Drive culvert road deck.
16+23	59.0	60.9	62.3	655	800	980	3.0	2.6	2.6	217	308	374	53.0	56.0	--	--	Wedgewood Drive culvert headwater.
16+48	59.0	60.9	62.3	655	800	980	3.0	2.6	2.6	218	308	374	53.1	56.0	--	--	
16+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.5	Floor 61.6	House on right bank.
18+58	59.2	61.0	62.3	620	760	930	6.8	4.4	3.9	92	174	237	53.1	57.0	--	--	
18+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.3	Floor 65.7	House on right bank.

Table 5. Selected data from hydraulic analysis of Akin Branch, simulation 2--Continued

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
19+70	60.0	61.3	62.5	620	760	930	4.0	3.7	3.5	155	208	265	55.0	58.0	--	--	Alpine Drive culvert tailwater.
20+00	60.0	61.3	61.8	620	760	930	5.8	5.6	6.4	106	135	146	55.3	--	61.8	64.0	Alpine Drive culvert outlet.
20+22	60.0	61.3	61.8	620	760	930	5.8	5.6	6.4	106	135	146	55.3	--	61.8	64.0	Alpine Drive culvert inlet.
20+22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	64.0	Alpine Drive road deck.
20+37	60.0	61.3	63.3	620	760	930	4.9	4.4	3.6	128	173	261	55.5	60.5	--	--	Alpine Drive culvert headwater.
20+50	60.0	61.3	63.3	620	760	930	5.2	4.8	3.9	120	160	240	55.6	60.5	--	--	
20+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 63.4	Floor 67.1	House on right bank.
22+22	60.9	61.7	63.5	580	710	870	8.3	7.3	5.0	70	98	174	58.0	63.0	--	--	Store culvert tailwater.
22+50	63.0	63.5	64.1	580	710	870	10.5	11.3	12.1	55	63	72	59.6	--	67.8	69.0	Store culvert outlet.

Table 5. Selected data from hydraulic analysis of Akin Branch, simulation 2--Continued

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
22+84	64.6	65.3	66.1	580	710	870	7.3	7.8	8.4	80	91	104	59.6	--	67.8	69.0	Store culvert inlet.
22+84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	69.0	Store culvert road deck.
23+00	64.7	65.4	66.2	580	710	870	4.2	4.2	4.2	139	168	20.5	59.2	65.0	--	--	Store culvert headwater.

Table 6. Selected data from hydraulic analysis of Akin Branch, simulation 3

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
14+25	58.7	60.2	61.3	655	800	980	3.5	2.8	2.7	189	288	360	51.5	56.0	--	--	
15+56	58.9	60.2	61.3	655	800	980	2.7	2.6	2.7	239	307	364	52.0	56.0	--	--	Wedgewood Drive culvert tailwater.
15+85	58.0	58.0	58.0	655	580	490	4.5	4.0	3.4	144	144	144	52.0	--	58.0	59.3	Wedgewood Drive culvert outlet.
16+07	58.0	58.0	58.0	655	580	490	4.5	4.0	3.4	144	144	144	52.0	--	58.0	59.3	Wedgewood Drive culvert inlet.
16+07	--	60.4	61.3	--	220	490	--	4.2	5.3	--	52	92	--	--	--	59.3	Wedgewood Drive culvert road deck.
16+23	59.2	60.5	61.5	655	800	980	2.7	2.7	2.8	243	302	349	52.5	56.0	--	--	Wedgewood Drive culvert headwater.
16+48	59.2	60.5	61.5	655	800	980	2.9	2.8	2.9	228	288	335	53.1	56.0	--	--	
16+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.5	Floor 61.6	House on right bank.
18+58	59.4	60.6	61.5	620	760	930	602	4.7	4.7	100	155	199	53.1	57.0	--	--	
18+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 59.3	Floor 65.7	House on right bank.

Table 6. Selected data from hydraulic analysis of Akin Branch, simulation 3--Continued

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
19+70	60.0	61.0	61.8	620	760	930	3.9	3.9	4.0	158	195	234	55.0	58.0	--	--	Alpine Drive culvert tailwater.
20+00	60.0	61.0	61.3	620	760	930	5.5	5.5	6.5	113	137	144	55.3	--	61.3	62.6	Alpine Drive culvert outlet.
20+22	60.1	61.0	61.3	620	760	930	5.4	5.5	6.5	115	137	144	55.3	--	61.3	62.6	Alpine Drive culvert inlet.
20+22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	62.6	Alpine Drive culvert road deck.
20+37	60.1	61.0	62.6	620	760	930	4.8	4.7	4.1	129	160	228	55.5	60.5	--	--	Alpine Drive culvert headwater.
20+50	60.1	61.0	62.6	620	760	930	5.1	5.1	4.4	121	150	210	55.6	60.5	--	--	
20+60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 63.4	Floor 67.1	House on right bank.
22+22	60.9	61.4	62.8	580	710	870	8.3	8.0	6.1	70	89	143	580	63.0	--	--	Store culvert tailwater.

Table 6. Selected data from hydraulic analysis of Akin Branch, simulation 3--Continued

[Add 564.29 to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 59 feet downstream from James Campbell Boulevard]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
22+50	63.0	63.5	64.1	580	710	870	10.5	11.3	12.1	55	63	72	59.6	--	67.8	69.0	Store culvert outlet.
22+84	64.6	65.3	66.1	580	710	870	7.3	7.8	8.4	80	91	104	59.6	--	67.8	69.0	Store culvert inlet.
22+84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	69.0	Store culvert road deck.
23+00	64.7	65.4	66.2	580	710	870	4.2	4.2	4.2	139	168	205	59.2	65.0	--	--	Store culvert headwater.

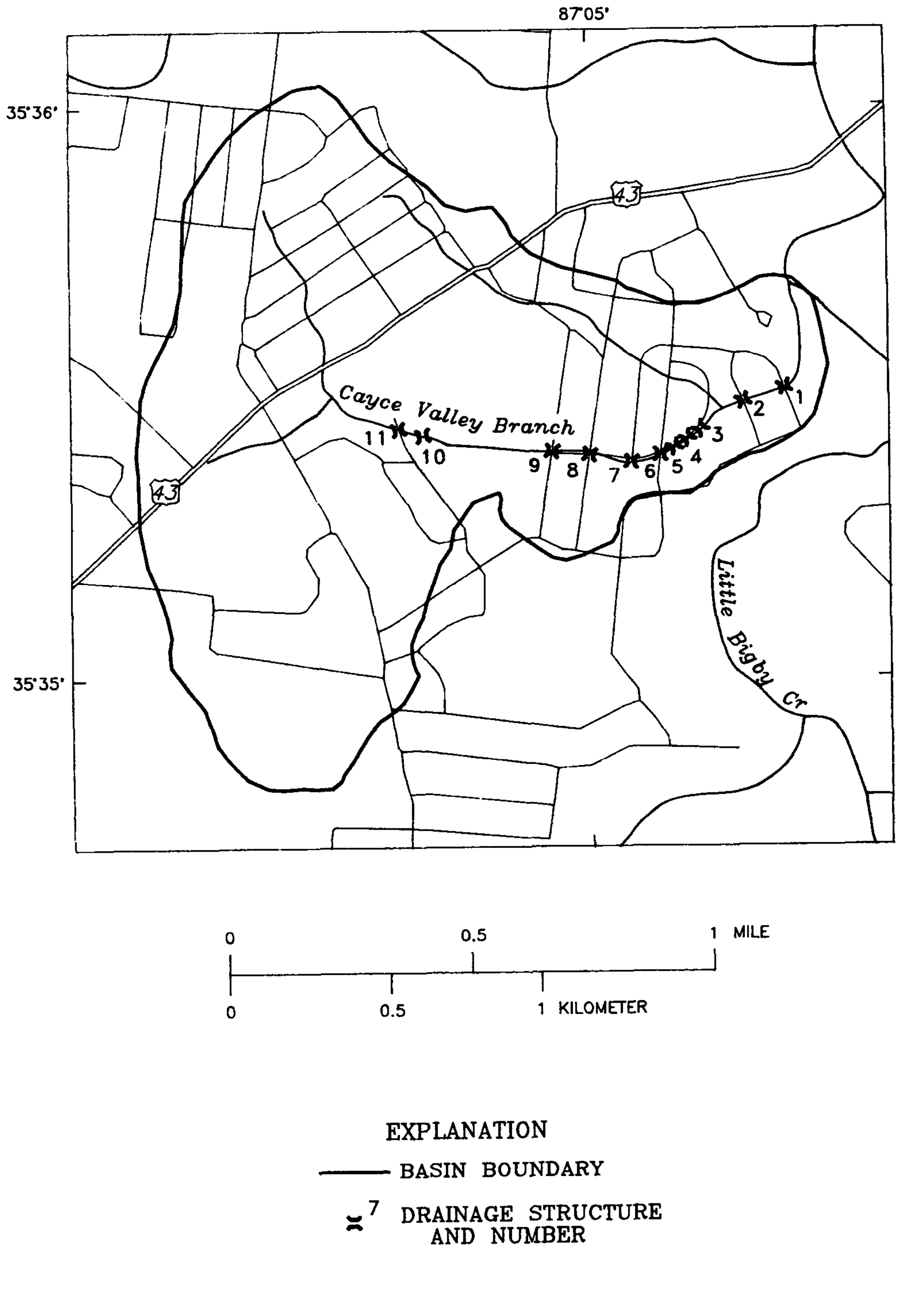


Figure 8. Location of drainage structures in the Cayce Valley Branch study reach.

Table 7. Cayce Valley Branch culvert and bridge inventory

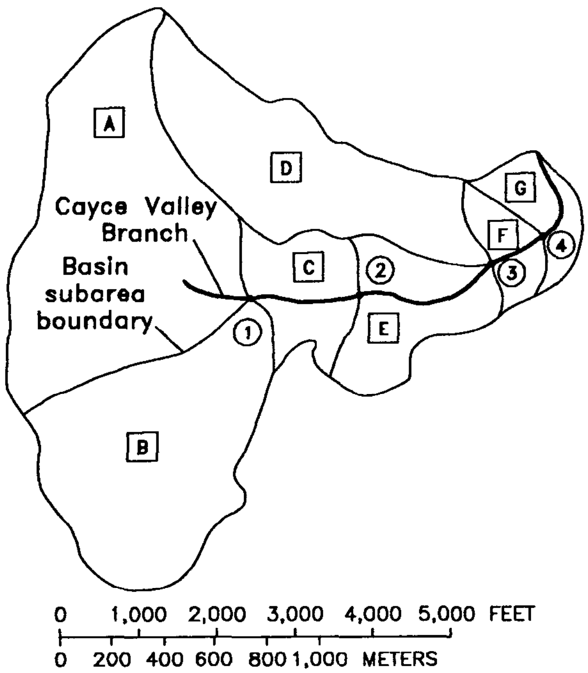
[Stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Structure number	Structure name	Stream stationing	Structure description
1	Whitney Drive culvert.	4+12 - 4+46	Two-barrel concrete pipe culvert. Barrel diameter, 4 feet. Length, 34 feet.
2	Mariner Drive culvert.	8+47 - 8+86	Three-barrel corrugated metal pipe culvert. Average barrel diameter, 4 feet. Length, 39 feet.
3	Foot bridge	12+06 - 12+22	Two-barrel smooth metal pipe culvert. Barrel diameter, 2 feet. Length, 16 feet.
4	Private driveway culvert.	13+06 - 13+22	Two-barrel concrete box culvert. Average barrel inlet, 5.4 feet x 4.1 feet. Length, 16 feet.
5	Private driveway culvert.	18+58 - 18+75	Two-barrel concrete box culvert. Average barrel inlet, 5.8 feet x 4.2 feet. Length, 17 feet.
6	Manor Road culvert.	21+16 - 21+36	One-barrel concrete box culvert. Barrel inlet, 13.6 feet x 4.1 feet. Length, 20 feet.
7	Cayce Valley Drive culvert.	24+36 - 24+68	One-barrel concrete box culvert. Barrel inlet, 12 feet x 3.2 feet. Length, 32 feet.
8	Windemere Drive culvert.	28+40 - 28+66	One-barrel concrete box culvert. Barrel inlet, 12 feet x 3.7 feet. Length, 26 feet.
9	Timberwood Drive culvert.	33+40 - 33+64	One-barrel concrete box culvert. Barrel inlet, 12 feet x 4.2 feet. Length, 24 feet.
10	Farm driveway culvert.	47+09 - 47+22	One-barrel timber deck culvert. Inlet, 9.2 feet x 4.7 feet. Length, 13 feet.
11	Jewell Drive culvert.	49+64 - 49+77	Two-barrel, corrugated metal pipe culvert. Barrel cross-sectional area, 11.5 ft^2. Length, 13 feet.

Flood Profiles

Flood profiles were computed for existing channel conditions for 5-, 10-, and 25-year recurrence interval floods at Cayce Valley Branch (fig. 10a-10d). No observed flood data are available for Cayce Valley Branch to use in calibrating the WSPRO model. The computed profiles indicate road overtopping of as much as 0.9 foot at Whitney Drive and 0.9 foot at Mariner Drive for the 25-year flood. The flood profiles also indicate the occurrence of backwater of as much as 5.3 feet at the upstream side of Whitney Drive and as much as 2.5 feet at Mariner Drive for the 25-year flood discharge. Hydraulic problems at these locations are attributed to undersized structures at both streets and a clogged channel downstream from Whitney Drive. Selected output from the hydraulic model has been tabulated to aid in interpretation of results (table 8).

CAYCE VALLEY BRANCH WATERSHED



EXPLANATION

(1) NODE AND NUMBER

[B] BASIN SUBAREA DESIGNATION

BASIN SUBAREA FLOOD DISCHARGES

Basin subarea	Area, in square miles	Percent of total flow	Discharge, in cubic feet per second, for indicated recurrence interval, in years		
			Q_5	Q_{10}	Q_{25}
A	0.345	33.2	135	165	210
B	.256	24.7	100	120	155
C	.072	6.9	25	35	40
D	.206	19.8	80	100	125
E	.090	8.7	35	45	55
F	.032	3.0	10	15	20
G	.039	3.7	15	20	25

BASIN FLOOD DISCHARGES

Node number	Stream stationing	Discharge, in cubic feet per second, for indicated recurrence interval, in years		
		Q_5	Q_{10}	Q_{25}
0 - 1	49+93 - 48+36	135	165	210
1 - 2	48+36 - 33+22	260	320	405
2 - 3	33+22 - 11+96	295	365	460
3 - 4	11+96 - 4+00	385	480	605

URBAN RUNOFF EQUATIONS (Robbins, 1984)

$Q_5 = 5.55\,(A)^{0.75}\,(IA)^{0.44}\,(P2\_24)^{2.53}$

$Q_{10} = 11.8\,(A)^{0.75}\,(IA)^{0.43}\,(P2\_24)^{2.12}$

$Q_{25} = 21.9\,(A)^{0.75}\,(IA)^{0.39}\,(P2\_24)^{1.89}$

P2_24 = 3.6 inches

Where

- Qn is the estimated flood discharge, in cubic feet per second, for the indicated recurrence interval, in years;
- A is the area of the watershed, in square miles;
- IA is the percentage of the drainage area that is impervious to infiltration of rainfall; and
- P2_24 is the 2-year 24-hour rainfall amount, in inches.

Average basin impervious area is 10 percent
Total basin area is 1.04 square miles

Total basin flows

$Q_5 = 5.55 \times 1.028 \times 2.75 \times 25.6 = 400$ cubic feet per second

$Q_{10} = 11.8 \times 1.028 \times 2.69 \times 15.1 = 495$ cubic feet per second

$Q_{25} = 21.9 \times 1.028 \times 2.45 \times 11.3 = 625$ cubic feet per second

Figure 9. Cayce Valley Branch flood discharge for selected recurrence intervals.

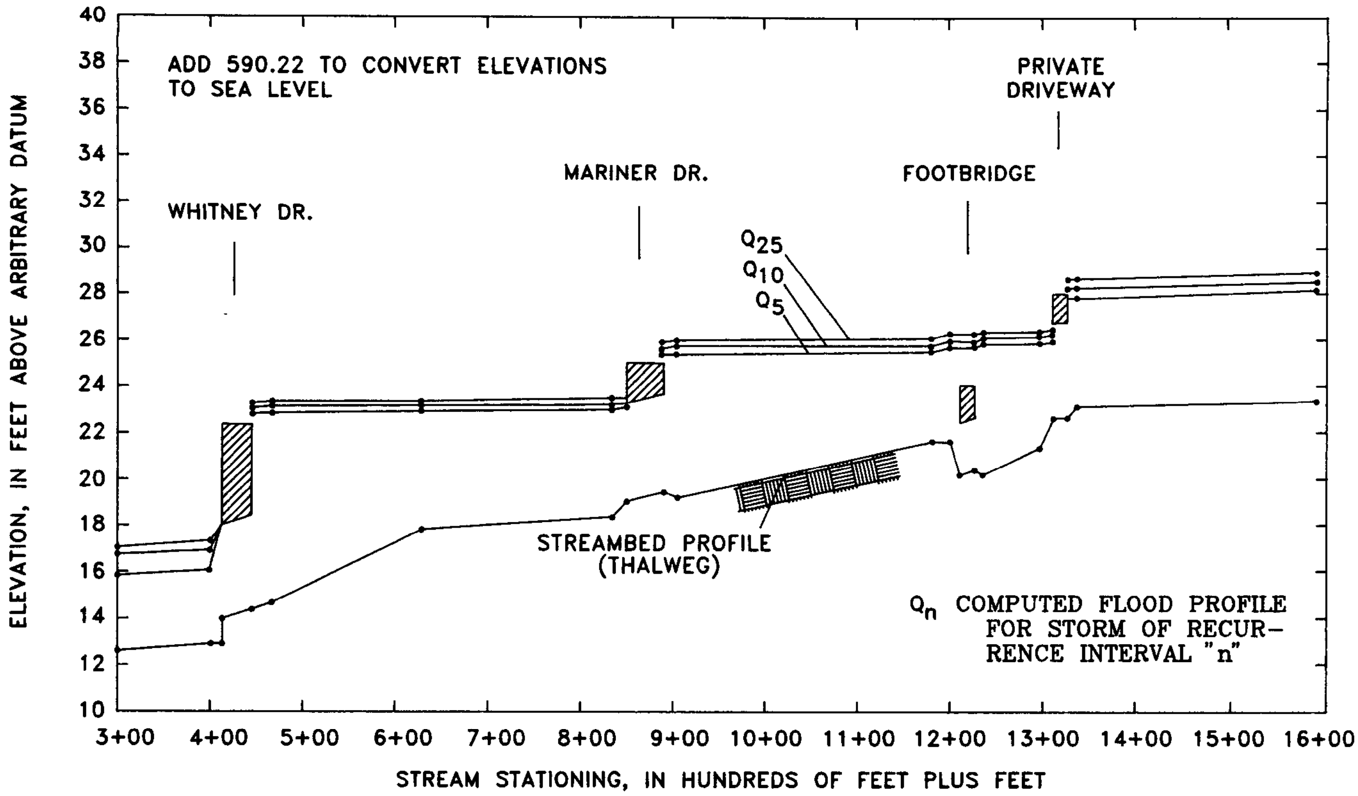


Figure 10a. Computed flood profiles, existing conditions, for Cayce Valley Branch.

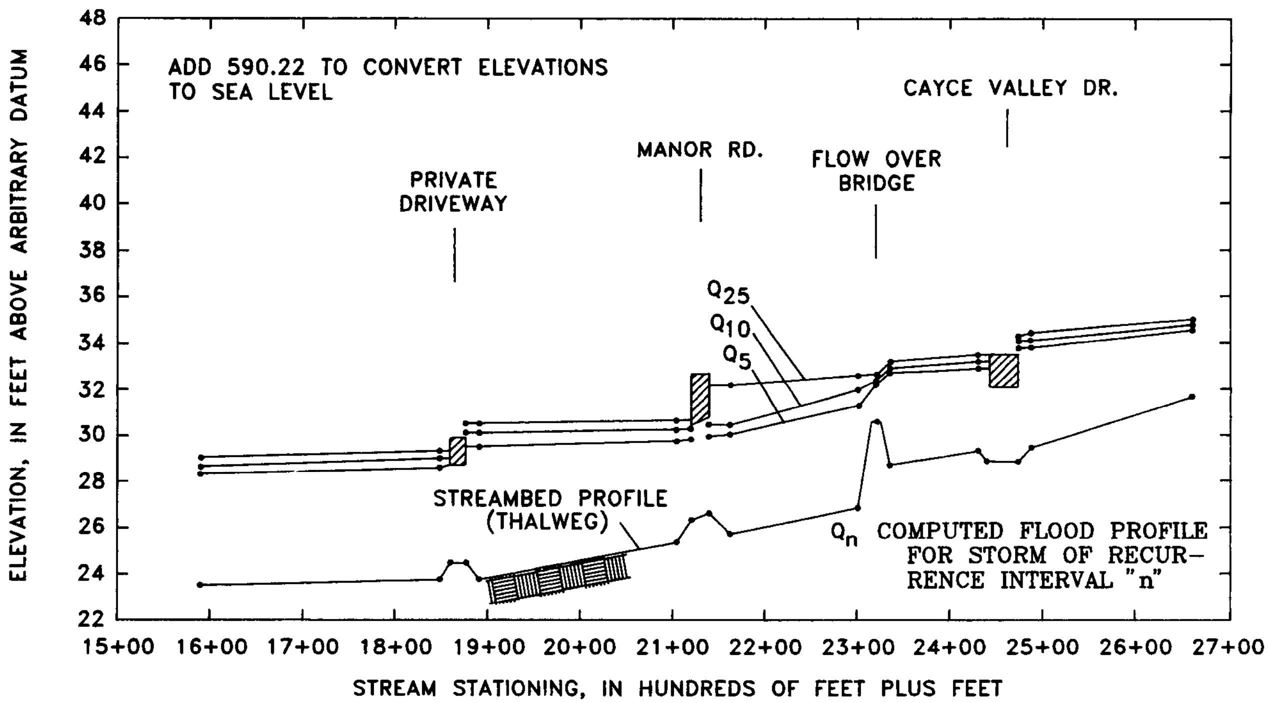


Figure 10b. Computed flood profiles, existing conditions, for Cayce Valley Branch--Continued.

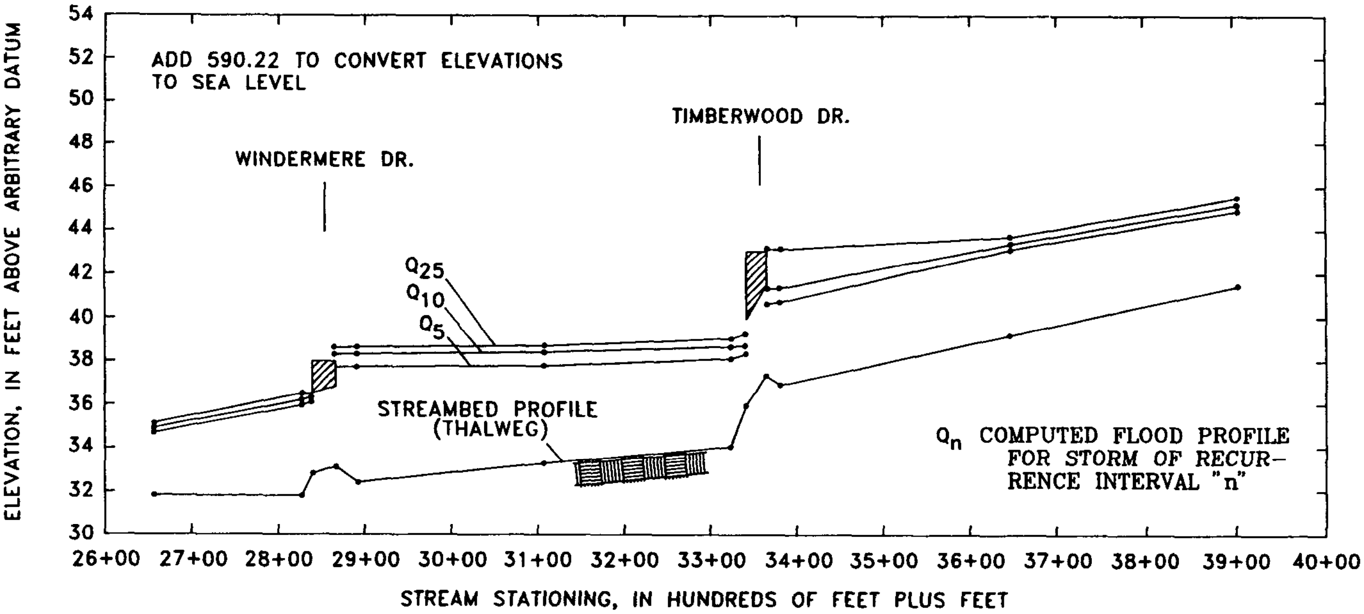


Figure 10c. Computed flood profiles, existing conditions, for Cayce Valley Branch--Continued.

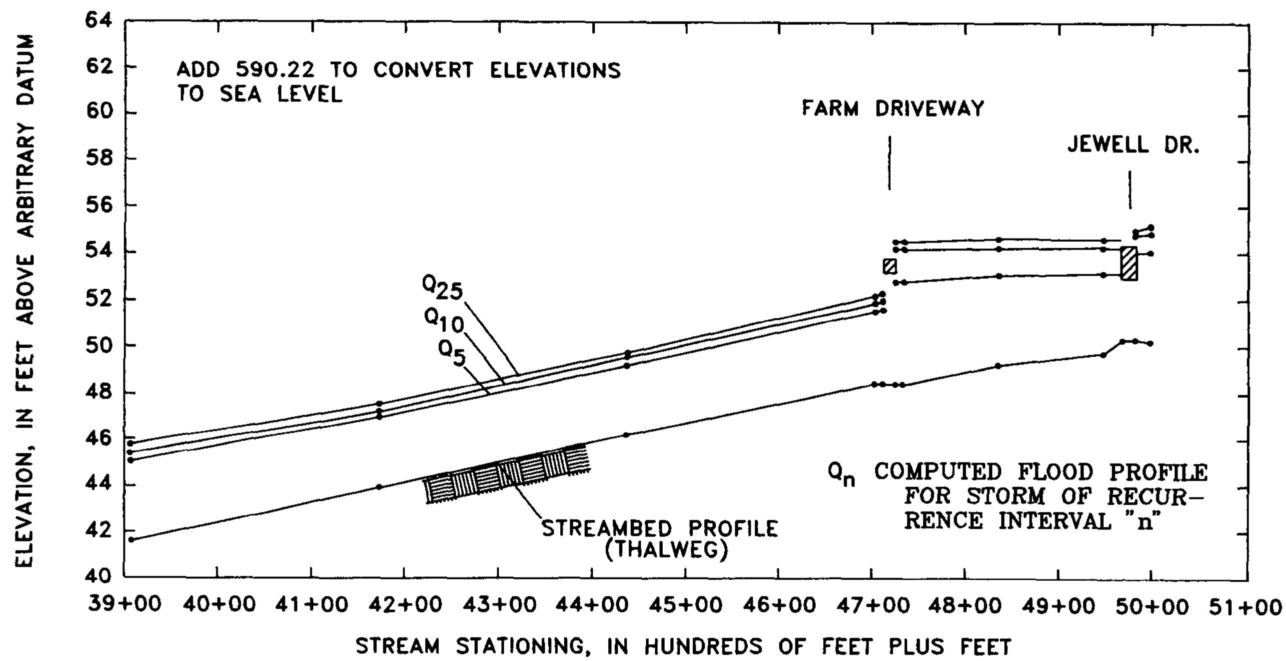


Figure 10d. Computed flood profiles, existing conditions, for Cayce Valley Branch--Continued.

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
3+00	15.8	16.7	17.0	385	480	605	8.9	7.1	7.4	43	68	82	12.6	16.2	--	--	
3+00	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 17.4	House 250 feet left of channel.
3+25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 17.6	House 130 feet right of channel.
4+00	16.1	16.9	17.3	385	480	605	8.9	7.1	7.4	43	67	82	12.9	16.5	--	--	Whitney Drive culvert tailwater.
4+12	18.0	18.0	18.0	260	265	275	10.4	10.6	11.0	25	25	25	14.0	--	18.0	22.3	Whitney Drive culvert outlet.
4+46	18.4	18.4	18.4	260	265	275	10.4	10.6	11.0	25	25	25	14.4	--	18.4	22.3	Whitney Drive culvert inlet.
4+46	22.8	23.0	23.2	125	215	330	2.7	3.3	3.7	46	65	89	--	--	--	22.3	Whitney Drive culvert road deck.
4+66	22.8	23.1	23.3	385	480	605	1.1	1.3	1.5	354	378	401	14.7	18.5	--	--	Whitney Drive culvert headwater.
5+50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 20.9	House 120 feet right of channel.
6+26	22.9	23.1	23.3	385	480	605	1.9	2.1	2.6	199	217	234	17.8	21.0	--	--	
7+87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 24.3	House 30 feet left of channel.

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
7+87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 24.6	House 30 feet right of channel.
8+32	23.0	23.2	23.5	385	480	605	4.1	4.6	5.3	94	104	114	18.4	21.0	--	--	Mariner Drive culvert tailwater.
8+47	23.1	23.3	23.3	300	310	320	8.9	8.4	8.6	35	37	37	19.1	--	23.3	25.0	Mariner Drive culvert outlet.
8+86	23.7	23.7	23.7	300	310	320	8.1	8.4	8.6	37	37	37	19.5	--	23.7	25.0	Mariner Drive culvert inlet.
8+86	25.4	25.6	25.9	85	170	285	2.3	3.0	3.8	37	57	75	--	--	--	25.0	Mariner Drive culvert road deck.
9+01	25.4	25.7	26.0	385	480	605	1.6	1.8	2.2	234	261	280	19.2	21.0	--	--	Mariner Drive culvert headwater.
9+66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 25.9	House 30 feet left of channel.
11+36	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 28.5	House 150 feet left of channel.
11+76	25.5	25.8	26.1	385	480	605	4.7	5.2	6.1	82	93	100	21.7	24.0	--	--	10 feet below tributary.
11+96	25.7	26.0	26.3	295	365	460	3.5	3.7	4.3	86	97	108	21.7	24.0	--	--	Footbridge tailwater.
12+06	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 28.5	House 50 feet right of channel.

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
12+06	22.5	22.5	22.5	15	15	15	2.1	2.1	2.1	7	7	7	20.3	--	22.5	24.1	Footbridge culvert outlet.
12+22	22.7	22.7	22.7	15	15	15	2.1	2.1	2.1	7	7	7	20.5	--	22.7	24.1	Footbridge culvert inlet.
12+22	25.7	26.0	26.3	280	350	445	4.4	4.6	5.1	64	76	87	--	--	--	24.1	Footbridge culvert deck.
12+32	25.9	26.2	26.4	295	365	460	2.4	2.7	3.2	122	134	145	20.3	24.0	--	--	Footbridge culvert headwater.
12+91	25.9	26.2	26.4	295	365	460	6.4	6.5	6.8	46	56	68	21.4	25.0	--	--	Private driveway culvert tailwater.
13+06	26.0	26.3	26.5	295	330	350	8.4	8.5	8.5	35	39	41	22.7	--	26.8	28.1	Private driveway culvert outlet.
13+22	26.8	26.8	26.8	295	330	350	6.8	7.5	8.0	44	44	44	22.7	--	26.8	28.1	Private driveway culvert inlet.
13+22	--	28.3	28.7	--	35	110	--	2.6	3.1	--	13	35	--	--	--	28.1	Private driveway culvert road deck.
13+32	27.9	28.3	28.7	295	365	460	2.7	2.7	2.9	111	135	158	23.2	25.0	--	--	Private driveway culvert headwater.

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
15+90	28.3	28.6	29.0	295	365	460	3.4	3.6	3.9	88	101	117	23.5	27.0	--	--	
18+47	28.6	29.0	29.3	295	365	460	3.6	3.8	4.1	82	96	111	23.8	27.0	--	--	Private driveway culvert tailwater.
18+59	28.7	28.7	28.7	295	335	350	6.1	6.8	7.1	49	49	49	24.5	--	28.7	29.9	Private driveway culvert outlet.
18+75	28.7	28.7	28.7	295	335	350	6.1	6.8	7.1	49	49	49	24.5	--	28.7	29.9	Private driveway culvert inlet.
18+75	--	30.1	30.5	--	30	110	--	2.3	3.1	--	13	35	--	--	--	29.9	Private driveway culvert road deck.
18+90	29.5	30.1	30.5	295	365	460	2.5	2.4	2.6	118	153	178	23.8	27.0	--	--	Private driveway culvert headwater.
21+01	29.8	30.3	30.7	295	365	460	5.3	5.2	5.4	56	71	85	25.4	28.5	--	--	Manor Road culvert tailwater.
21+16	29.9	30.3	30.5	295	365	460	6.1	6.9	8.2	48	53	56	26.4	--	30.5	32.7	Manor Road culvert outlet.
21+36	30.0	30.5	30.8	295	365	460	6.6	7.0	8.2	45	52	56	26.7	--	30.8	32.7	Manor Road culvert inlet.

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
21+36	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32.7	Manor Road culvert road deck.
21+60	30.1	30.5	32.2	295	365	460	5.9	6.3	4.6	50	58	101	25.8	30.0	--	--	Manor Road culvert headwater.
22+98	31.4	32.1	32.7	295	365	460	6.3	5.3	4.8	47	69	95	27.0	31.0	--	--	Flow over bridge tailwater.
23+18	32.3	32.4	32.7	295	365	460	6.3	6.9	7.1	47	53	65	30.7	--	--	--	Flow over bridge.
23+33	32.8	33.0	33.3	295	365	460	3.8	4.2	4.6	79	88	100	28.8	--	--	--	Flow over bridge headwater.
24+26	33.0	33.3	33.6	295	365	460	4.6	5.0	5.4	64	72	85	29.4	31.0	--	--	Cayce Valley Drive culvert tailwater.
24+36	32.2	32.2	32.2	230	230	225	6.0	6.0	5.9	38	38	38	29.0	--	32.2	33.6	Cayce Valley Drive culvert outlet.
24+68	32.2	32.2	32.2	230	230	225	6.0	6.0	5.9	38	38	38	29.0	--	32.2	33.6	Cayce Valley Drive culvert inlet.
24+68	33.9	34.2	34.4	65	135	235	2.3	3.0	3.6	28	45	65	--	--	--	33.6	Cayce Valley Drive culvert road deck.
24+83	33.9	34.2	34.5	295	365	460	2.1	2.2	2.5	142	164	187	29.6	31.5	--	--	Cayce Valley Drive culvert headwater.

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
26+56	34.7	34.9	35.1	295	365	460	6.0	6.3	6.9	49	58	67	31.8	33.0	--	--	
28+28	36.0	36.2	36.5	295	365	460	5.4	5.8	6.3	55	63	73	31.8	34.5	--	--	Windemere Drive culvert headwater.
28+40	36.1	36.3	36.5	295	335	395	7.6	8.0	9.0	39	42	44	32.8	--	36.5	38.0	Windemere Drive culvert outlet.
28+66	36.8	36.8	36.8	295	335	395	6.7	7.6	9.0	44	44	44	33.1	--	36.8	38.0	Windemere Drive culvert inlet.
28+66	--	38.3	38.6	--	30	65	--	2.4	3.1	--	13	21	--	--	--	38.0	Windemere Drive culvert road deck.
28+91	37.7	38.3	38.6	295	365	460	2.5	2.5	3.0	118	144	154	32.4	35.0	--	--	Windemere Drive culvert headwater.
31+07	37.8	38.4	38.7	295	365	460	3.6	3.4	3.9	83	108	119	33.3	35.5	--	--	
33+22	38.2	38.7	39.1	260	320	405	4.7	4.6	5.0	55	70	80	34.1	37.0	--	--	Timberwood Drive culvert tailwater.
33+40	38.4	38.8	39.3	260	320	390	9.0	9.5	10.0	29	34	39	36.0	--	40.2	41.5	Timberwood Drive culvert outlet.
33+64	40.7	41.4	41.6	260	320	390	6.7	6.8	7.8	39	47	50	37.4	--	41.6	43.1	Timberwood Drive culvert inlet.
33+64	--	--	43.2	--	--	15	--	--	3.1	--	--	5	--	--	--	43.1	Timberwood Drive culvert road deck.

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
33+80	40.8	41.4	43.2	260	320	405	4.3	3.9	2.7	61	82	153	37.0	40.0	--	--	Timberwood Drive culvert headwater.
36+44	43.2	43.5	43.8	260	320	405	5.5	5.8	6.1	47	55	66	39.3	42.0	--	--	
39+07	45.0	45.3	45.6	260	320	405	4.4	4.7	5.0	59	69	81	41.6	43.0	--	--	
41+71	47.0	47.2	47.5	260	320	405	5.8	5.8	6.0	45	55	67	43.9	45.5	--	--	
44+35	49.2	49.5	49.7	260	320	405	4.8	5.0	5.4	55	64	75	46.2	47.5	--	--	
46+99	51.6	51.9	52.2	260	320	405	5.6	5.9	6.1	46	54	66	48.5	50.5	--	--	Farm driveway culvert tailwater.
47+09	51.6	52.0	52.3	260	285	315	9.0	8.9	9.0	29	32	35	48.5	--	53.2	53.8	Farm driveway culvert outlet.
47+22	52.8	53.2	53.2	260	285	315	6.5	6.6	7.3	40	43	43	48.5	--	53.2	53.8	Farm driveway culvert inlet.
47+22	--	54.2	54.5	--	35	90	--	2.6	3.3	--	13	27	--	--	--	53.8	Farm driveway culvert road deck.
47+29	52.8	54.2	54.5	260	320	405	2.9	2.2	2.6	90	143	156	48.5	50.5	--	--	Farm driveway culvert headwater.
48+36	53.1	54.3	54.7	135	165	210	1.7	1.3	1.5	80	127	142	49.3	52.0	--	--	

Table 8. Selected data from hydraulic analysis of Cayce Valley Branch, existing conditions--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
49+44	53.2	54.3	54.7	135	165	210	2.0	1.6	1.8	67	104	119	49.8	53.0	--	--	Jewell Drive culvert tailwater.
49+64	53.0	53.0	53.0	135	115	110	5.9	5.0	4.8	23	23	23	50.4	--	53.0	54.4	Jewell Drive culvert outlet.
49+77	53.0	53.0	53.0	135	115	110	5.9	5.0	4.8	23	23	23	50.4	--	53.0	54.4	Jewell Drive culvert inlet.
49+77	--	54.9	55.1	--	50	100	--	2.7	3.4	--	19	29	--	--	--	54.4	Jewell Drive culvert road deck.
49+93	54.1	54.9	55.2	135	165	210	1.4	1.3	1.5	95	130	143	50.3	53.0	--	--	Jewell Drive culvert headwater.

Simulation of Effects of Alternative Drainage Structures

The hydraulic model was used to simulate the flood profiles at Cayce Valley Branch resulting from possible alternative designs for selected drainage structures. Data on existing structure sizes are listed in table 7, and the alternative drainage improvement designs evaluated using the model are described below for model simulations 1 and 2.

Simulation 1: A concrete box culvert with a barrel width of 10 feet, barrel height of 5 feet, and culvert length of 30 feet was simulated at Whitney Drive. A concrete box culvert with a barrel width of 10 feet, barrel height of 4.5 feet, and culvert length of 30 feet was simulated at Mariner Drive.

Simulation 2: A concrete box culvert with a barrel width of 10 feet, barrel height of 6 feet, and length of 30 feet was simulated at Whitney Drive. A concrete box culvert with a barrel width of 12 feet, barrel height of 4.5 feet, and length of 30 feet was simulated at Mariner Drive.

The simulated flood profiles for the two conditions (figs. 11 and 12) indicate that during a 25-year flood: Drainage improvements modeled in simulation 1 would result in a decrease of 0.6 foot in water-surface elevation upstream from Whitney Drive and a decrease of 0.3 foot in the water-surface elevation upstream from Mariner Drive (table 9, fig. 11). Drainage improvements modeled in simulation 2 would result in a decrease of 0.8 foot in water-surface elevation upstream from Whitney Drive and a decrease of 0.4 foot in water-surface elevation upstream from Mariner Drive (table 10, fig. 12).

SUMMARY

A flood study was conducted at Akin Branch and Cayce Valley Branch in the Little Bigby Creek watershed during 1990 and 1991. Major elements of the study included: estimation of flood discharges at points along Akin Branch and Cayce Valley Branch for selected recurrence intervals, simulation of flood profiles corresponding to estimated flood discharges for existing conditions at Akin Branch and Cayce Valley Branch, analysis of changes to flood profiles likely to result from possible drainage improvements such as enlarged box culverts at selected sites on Akin Branch and Cayce Valley Branch.

Flood discharges at the mouths of Akin Branch and Cayce Valley Branch were computed for 5-, 10-, and 25-year recurrence intervals using flood-frequency relations applicable to small urban streams in Tennessee. Flood discharges at points upstream from the mouth were estimated by subdividing the watershed and assigning a percentage of the discharge at the mouth, based on drainage area, to each subarea.

Flood profiles corresponding to the computed flood discharges were simulated for existing conditions at Akin Branch and Cayce Valley Branch using WSPRO, a computer model for water-surface profile computations. Computed flood profiles for existing conditions indicate excessive backwater problems at Wedgewood Drive and Alpine Drive on Akin Branch and at Whitney Drive and Mariner Drive on Cayce Valley Branch. On Akin Branch, these problems include road overtopping of as much as 2.5 feet at Wedgewood Drive and as much as 1.5 feet at Alpine Drive for the 25-year flood. The profiles also indicate backwater of about 1.4 feet at Alpine Drive. On Cayce Valley Branch, these problems include road overtopping of as much as 0.9 foot at Whitney Drive and Mariner Drive. Simulated backwater during a 25-year flood totaled as much as 5.3 feet at Whitney Drive and as much as 2.5 feet at Mariner Drive.

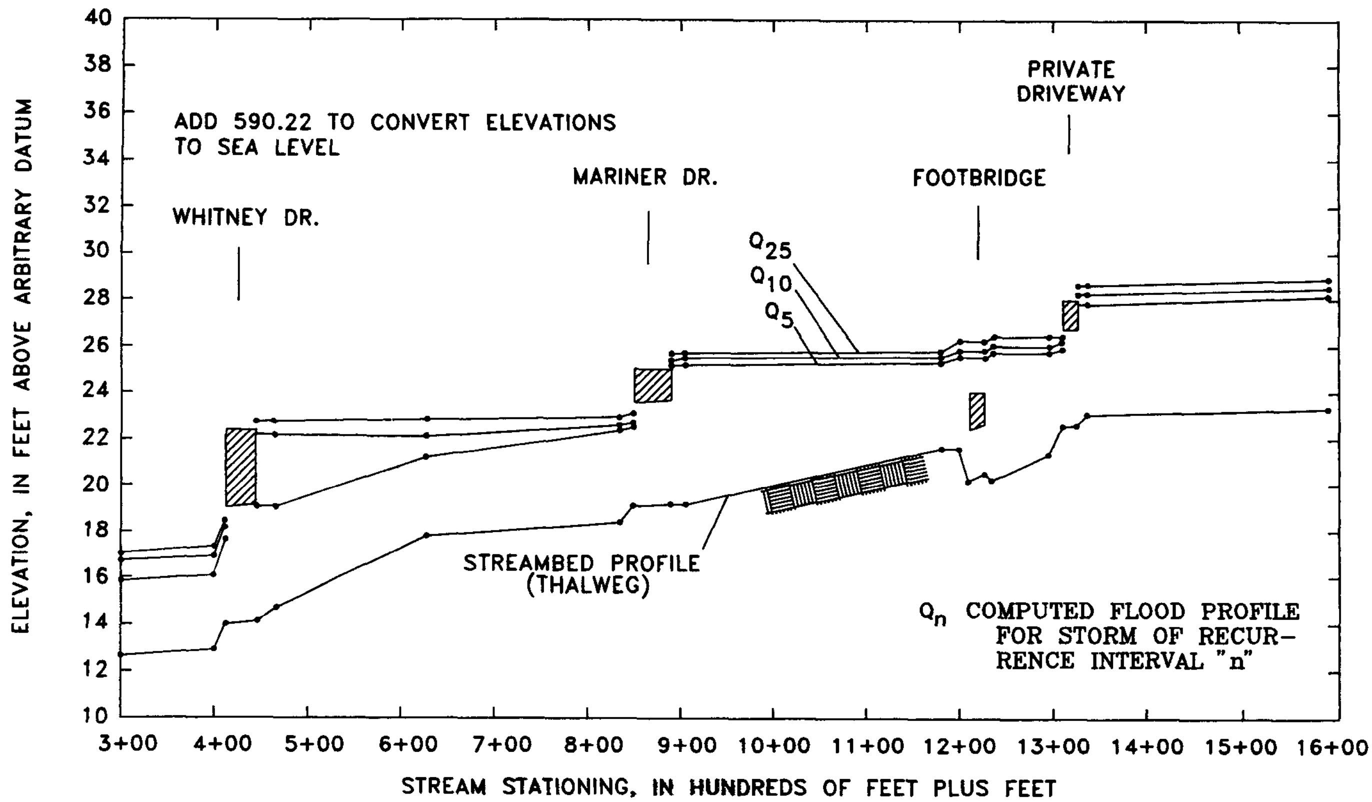


Figure 11. Computed flood profiles for Cayce Valley Branch, simulation 1.

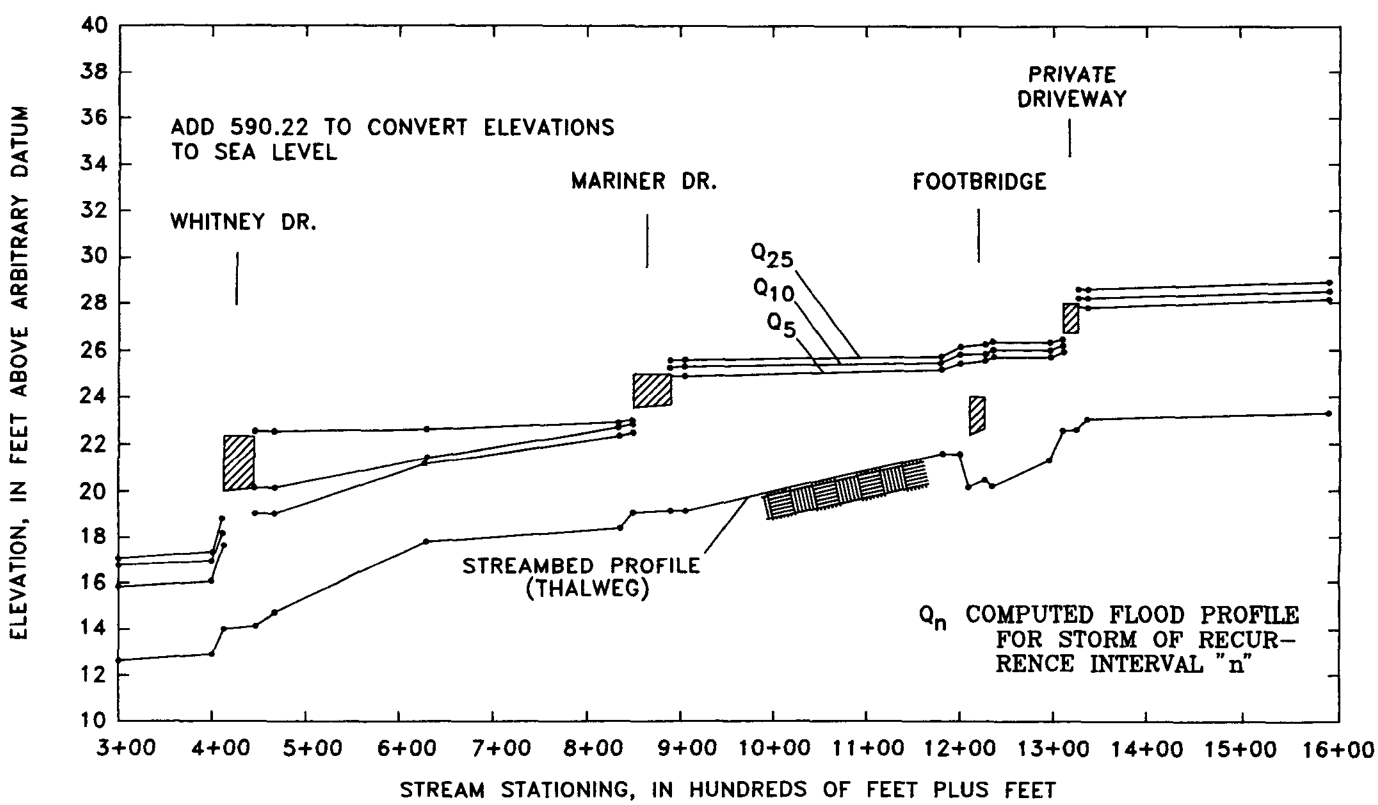


Figure 12. Computed flood profiles, for Cayce Valley Branch, simulation 2.

Table 9. Selected data from hydraulic analysis of Cayce Valley Branch, simulation 1

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
3+00	15.8	16.7	17.0	385	480	605	8.9	7.1	7.4	43	68	82	12.6	16.2	--	--	
3+00	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 17.4	House 250 feet left of channel.
3+25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 17.6	House 130 feet right of channel.
4+00	16.1	16.9	17.3	385	480	605	8.9	7.1	7.4	43	67	82	12.9	16.5	--	--	Whitney Drive culvert tailwater.
4+12	17.6	18.2	18.4	385	480	505	10.7	11.4	11.5	36	42	44	14.0	--	19.0	22.3	Whitney Drive culvert outlet.
4+46	19.0	19.0	19.0	385	480	505	7.7	9.6	10.1	50	50	50	14.1	--	19.1	22.3	Whitney Drive culvert inlet.
4+46	--	--	22.7	--	--	100	--	--	2.5	--	--	40	--	--	--	22.3	Whitney Drive culvert road deck.
4+66	19.0	22.1	22.7	385	480	605	7.0	1.7	1.8	55	279	343	14.7	18.5	--	--	Whitney Drive culvert headwater.

Table 9. Selected data from hydraulic analysis of Cayce Valley Branch, simulation 1--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
5+50	--	--	--	--	--	--	--	--	-	--	--	--	--	--	--	Ground 20.9	House 120 feet right of channel.
6+26	21.2	22.1	22.8	385	480	605	5.0	3.3	3.1	77	147	194	17.8	21.0	--	--	
7+87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 24.3	House 30 feet left of channel.
7+87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 24.6	House 30 feet right of channel.
8+32	22.4	22.6	23.0	385	480	605	5.2	6.0	6.2	74	80	97	18.4	21.0	--	--	Mariner Drive culvert tailwater.
8+47	22.5	22.7	23.1	345	360	380	10.1	10.0	9.5	34	36	40	19.1	--	23.6	25.0	Mariner Drive culvert outlet.
8+86	23.7	23.7	23.7	345	360	380	7.7	8.0	8.4	45	45	45	19.2	--	23.7	25.0	Mariner Drive culvert inlet.
8+86	25.2	25.4	25.7	40	120	225	1.9	2.6	3.3	21	46	68	--	--	--	25.0	Mariner Drive culvert road deck.
9+01	25.2	25.5	25.7	385	480	605	1.8	2.0	2.3	217	243	269	19.2	21.0	--	--	Mariner Drive culvert headwater.

Table 9. Selected data from hydraulic analysis of Cayce Valley Branch, simulation 1--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
9+66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 25.9	House 30 feet left of channel.
11+36	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 28.5	House 150 feet left of channel.
11+76	25.4	25.6	25.9	385	480	605	5.0	5.5	6.2	77	87	98	21.7	24.0	--	--	10 feet below tributary.
11+96	25.6	25.9	26.3	295	365	460	3.6	3.9	4.3	82	94	108	21.7	24.0	--	--	Footbridge culvert tailwater.
12+06	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 28.5	House 50 feet right of channel.
12+06	22.5	22.5	22.5	15	15	15	2.1	2.1	2.1	7	7	7	203	--	22.5	24.1	Footbridge culvert outlet.
12+22	22.7	22.7	22.7	15	15	15	2.1	2.1	2.1	7	7	7	205	--	22.7	24.1	Footbridge culvert inlet.
12+22	25.6	25.9	26.3	280	350	445	4.7	4.8	5.1	60	73	88	--	--	--	24.1	Footbridge culvert deck.
12+32	25.8	26.1	26.5	295	365	460	2.5	2.9	3.1	116	128	147	20.3	24.0	--	--	Footbridge culvert headwater.

Table 9. Selected data from hydraulic analysis of Cayce Valley Branch, simulation 1--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
12+91	25.8	26.1	26.5	295	365	460	6.6	6.7	6.4	45	54	72	21.4	25.0	--	--	Cayce Valley Drive driveway culvert tailwater.

Table 10. Selected data from hydraulic analysis of Cayce Valley Branch, simulation 2

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
3+00	15.8	16.7	17.0	385	480	605	8.9	7.1	7.4	43	68	82	12.6	16.2	--	--	
3+00	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 17.4	House 250 feet left of channel.
3+25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 17.6	House 130 feet right of channel.
4+00	16.1	16.9	17.3	385	480	605	8.9	7.1	7.4	43	67	82	12.9	16.5	--	--	Whitney Drive culvert tailwater.
4+12	17.6	18.2	18.8	385	480	560	10.7	11.4	11.7	36	42	48	14.0	--	20.0	22.3	Whitney Drive culvert outlet.
4+46	19.0	20.1	20.1	385	480	560	6.4	8.0	9.3	50	60	60	14.1	--	20.1	22.3	Whitney Drive culvert inlet.
4+46	--	--	22.5	--	--	45	--	--	1.9	--	--	24	--	--	--	22.3	Whitney Drive culvert deck road.
4+66	19.0	20.1	22.5	385	480	605	7.0	4.4	1.9	55	108	320	14.7	18.5	--	--	Whitney Drive culvert headwater.
5+50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 20.9	House 120 feet right of channel.

Table 10. Selected data from hydraulic analysis of Cayce Valley Branch, simulation 2--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
6+26	21.2	21.4	22.6	385	480	605	5.0	5.4	3.4	77	89	177	17.8	21.0	--	--	
7+87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 24.3	House 30 feet left of channel.
7+87	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 24.6	House 30 feet right of channel.
8+32	22.4	22.7	22.9	385	480	605	5.2	5.8	6.5	74	83	93	18.4	21.0	--	--	Mariner Drive culvert tailwater.
8+47	22.5	22.8	23.0	385	420	440	9.4	9.5	9.4	41	44	47	19.1	--	23.6	25.0	Mariner Drive culvert outlet.
8+86	23.7	23.7	23.7	385	420	440	7.1	7.8	8.2	54	54	54	19.2	--	23.7	25.0	Mariner Drive culvert inlet.
8+86	--	25.3	25.6	--	60	165	--	2.2	3.0	--	27	55	--	--	--	25.0	Mariner Drive culvert road deck.
9+01	24.9	25.3	25.6	385	480	605	2.1	2.1	2.4	188	225	254	19.2	21.0	--	--	Mariner Drive culvert headwater.
9+66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 25.9	House 30 feet left of channel.

Table 10. Selected data from hydraulic analysis of Cayce Valley Branch, simulation 2--Continued

[Add 590.22 feet to convert elevations to sea level; --, no data; stream stationing is given in hundreds of feet plus feet from a point 412 feet downstream from Whitney Drive]

Stream stationing	Water-surface elevation (feet)			Flow (cubic feet per second)			Mean velocity (feet per second)			Cross-sectional area of flow (square feet)			Channel bed elevation (feet)	Bank full elevation (feet)	Low steel elevation (feet)	Deck elevation (feet)	Remarks
	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr	5 yr	10 yr	25 yr					
11+36	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 28.5	House 150 feet left of channel.
11+76	25.2	25.5	25.8	385	480	605	5.5	5.8	6.5	70	82	93	21.7	24.0	--	--	10 feet below tributary.
11+96	25.5	25.9	26.2	295	365	460	3.7	4.0	4.3	79	91	106	21.7	24.0	--	--	Footbridge culvert tailwater.
2+06	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Ground 28.5	House 50 feet right of channel.
12+06	22.5	22.5	22.5	15	15	15	2.1	2.1	2.1	7	7	7	20.3	--	22.5	24.1	Footbridge culvert outlet.
12+22	22.7	22.7	22.7	15	15	15	2.1	2.1	2.1	7	7	7	20.5	--	22.7	24.1	Footbridge culvert inlet.
12+22	25.6	25.9	26.3	280	350	445	4.8	4.9	5.2	58	71	86	--	--	--	24.1	Footbridge culvert deck.
12+32	25.8	26.1	26.4	295	365	460	2.5	2.8	3.2	118	130	145	20.3	24.0	--	--	Footbridge culvert headwater.
12+91	25.8	26.1	26.4	295	365	460	6.5	6.7	7.0	45	54	66	21.4	25.0	--	--	Cayce Valley Drive driveway culvert tailwater.

The USGS Water-Surface Profile (WSPRO) computation model was used to simulate the effects on existing flood profiles that might be expected if the culverts and bridges at these locations were enlarged. For the alternative designs studied, simulation 3 for Akin Branch indicated that the water-surface elevations during a 25-year flood would probably decrease by 0.2 foot upstream of Wedgewood Drive and would decrease by 0.9 foot upstream of Alpine Drive. For Cayce Valley Branch, simulation 2 indicated that the water-surface elevations during a 25-year flood would probably decrease by 0.8 foot upstream of Whitney Drive and decrease by 0.4 foot upstream of Mariner Drive. Reduced backwater was indicated at all locations.

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