Base (100-Year) Flood Elevations for Selected Sites in Montgomery County, Missouri

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ABSTRACT

The primary requirement for community participation in the National Flood Insurance Program is the adoption and enforcement of floodplain management requirements that minimize the potential for flood damages to new construction and avoid aggravating existing flooding conditions. This report provides base (100-year) flood elevations for use in the management and regulation of eight flood-hazard areas designated by the Federal Emergency Management Agency as approximate Zone A areas in Montgomery County, Missouri.

Three sites are in the Missouri River floodplain at the communities of Rhineland (BFE 1), Bluffton (BFE 2), and McKittrick (BFE 3), Missouri. A two-dimensional model was used to simulate the lateral and longitudinal variations in the 100-year water-surface elevations across the Missouri River floodplain. The base (100-year) water-surface elevations at BFE 1, BFE 2, and BFE 3 are 521.5, 527.2, and 516.0 feet above sea level. A one-dimensional model was used for the other sites. Three sites are located in urban basins at Montgomery City (BFE 4), New Florence (BFE 5), and Jonesburg (BFE 6), Missouri. The base (100-year) water-surface elevations at BFE 4, BFE 5, and BFE 6 are 766.0, 826.5, and 851.7 feet above sea level. Two sites are located in the rural Loutre River Basin at Mineola (BFE 7) and Big Spring (BFE 8), Missouri. The base (100-year) water-surface elevations at BFE 7 and BFE 8 are 568.6 and 535.6 feet above sea level.

INTRODUCTION

In 1968, the United States Congress passed the National Flood Insurance Act, which created the National Flood Insurance Program. Congress recognized that the success of this program requires that community participation be widespread, and that flood insurance studies be conducted to accurately assess the flood risk within each participating flood-prone community (U.S. Department of Housing and Urban Development, 1995).

The Housing and Urban Development Act of 1969 expanded participation in the National Flood Insurance Program by authorizing an Emergency Program under which insurance coverage could be provided before completion of the communities' detailed flood-insurance studies. Before these studies could be conducted for the communities, Flood Hazard Boundary Maps were prepared using either available data or approximate engineering methods. The Flood Hazard Boundary Maps identify the approximate areas within a community subject to inundation by a 100-year recurrence-interval flood. These areas are referred to as Zone A areas on the boundary maps. Zone A areas have a one percent chance of being inundated by a 100-year flood flow in any given year. The Flood Hazard Boundary Map was intended to assist communities in managing floodplain development, and insurance agents and property owners in identifying areas where the purchase of flood insurance was advisable (U.S. Department of Housing and Urban Development, 1995).

The Flood Disaster Protection Act of 1973, which amended the 1968 National Flood Insurance Act, required that flood-prone communities be notified of their flood hazards to encourage insurance program participation. This was accomplished through publishing Flood Hazard Boundary Maps for all communities that were identified as containing flood-hazard areas. The initial Flood Hazard Boundary Maps were prepared using results from detailed flood insurance studies. As early as 1976, the Federal Emergency Management Agency (FEMA) recognized that some communities did not require a detailed flood study because few buildings existed in the floodplain, and development plans were minimal. Shortly thereafter, FEMA began designating communities with limited existing and planned development in floodplains as having approximate Zone A areas on the Flood Insurance Rate Map (U.S. Department of Housing and Urban Development, 1995). To minimize study costs, the approximate Zone A areas were to be analyzed using less detailed methodologies than those used in detailed flood-insurance studies.

In areas designated as approximate Zone A, where base (100-year) flood elevations (BFEs) have not been provided by FEMA, communities must adopt and enforce floodplain management regulations that meet minimal National Flood Insurance Program standards (U.S. Department of Housing and Urban Development, 1995). However, in Zone A areas where base flood elevations are determined, communities are better able to manage and protect property susceptible to floods equal to or less than a 100-year base flood. The U.S. Geological Survey, in cooperation with the State Emergency Management Agency, has completed a study using one- and two-dimensional surface-water flow-models to compute base flood elevations for eight approximate Zone A sites in Montgomery County, Missouri. This report presents the results of that study.

DESCRIPTION OF THE STUDY AREA

Montgomery County (fig. 1), population of about 11,500, is in the east-central part of Missouri and covers about 533 square miles. Montgomery City, in west-central Montgomery County, is the county seat and largest town in the county. Although there is some business and industry, most of the county is economically dependent on farming or farm-related businesses. Livestock, mostly beef cattle and hogs, are the biggest income products. About 65 percent of the county is cropland, about 20 percent is woodland, and the remainder is open pasture land. Corn, soybeans, and wheat are the principal crops. The sale of timber products also is important economically in the southern part of the county.

Topography varies greatly in Montgomery County, ranging from nearly-level to moderately-sloping prairie (north) to very steep hillsides and vertical cliffs (south). However, the topographic features in the county do not significantly affect the climate, which is variable during all seasons. Most precipitation generally occurs in May and June, but there are no sharp seasonal changes in precipitation. The average precipitation for December, January, and February is about 15 percent of the annual total (approximately 36 inches), as compared to 25 to 30 percent for March through May, June through August, and September through November.

HYDROLOGIC AND HYDRAULIC ANALYSES

Several hydrologic or hydraulic methods can be used to compute flood discharges for approximate Zone A areas. For this study, the peak discharge of the base (100-year) flood for the Missouri River (near Hermann, Missouri) study reach (BFE 1–3; fig. 1) was obtained from U.S. Army Corps of Engineers (M. Vanderpool, written commun., 1997) flood frequency analyses. Because the flood data for Montgomery County streams are hydrologically inadequate, the 100-year regression equation from Becker (1986) was used to compute the peak-discharge for the base (100-year) flood for three small urban Zone A sites (BFE 4–6). The remaining two Zone A sites (BFE 7 and 8) were considered to be rural and were computed from the 100-year regression equation in Alexander and Wilson (1995). The regression equations involve determining specific basin parameters—for example, drainage area and percent of impervious area (urban streams) or drainage area and main-channel slope (rural streams).

There are various hydraulic methods that can be used to determine peak-flood elevations at selected locations on Missouri streams. Two methods were used for this study. The two-dimensional finite-element surface-water flow-modeling system, FESWMS, was used to compute the Missouri River sites BFE 1 to 3 base (100-year) flood elevations. The FESWMS model was selected to enable computations of steady-state flow with both lateral and longitudinal variations in velocity and water-surface elevation (Lee and Froehlich, 1989). The one-dimensional surface-water flow model, HEC-RAS, developed by the U.S. Army Corps of Engineers (1997), was used to compute the sites

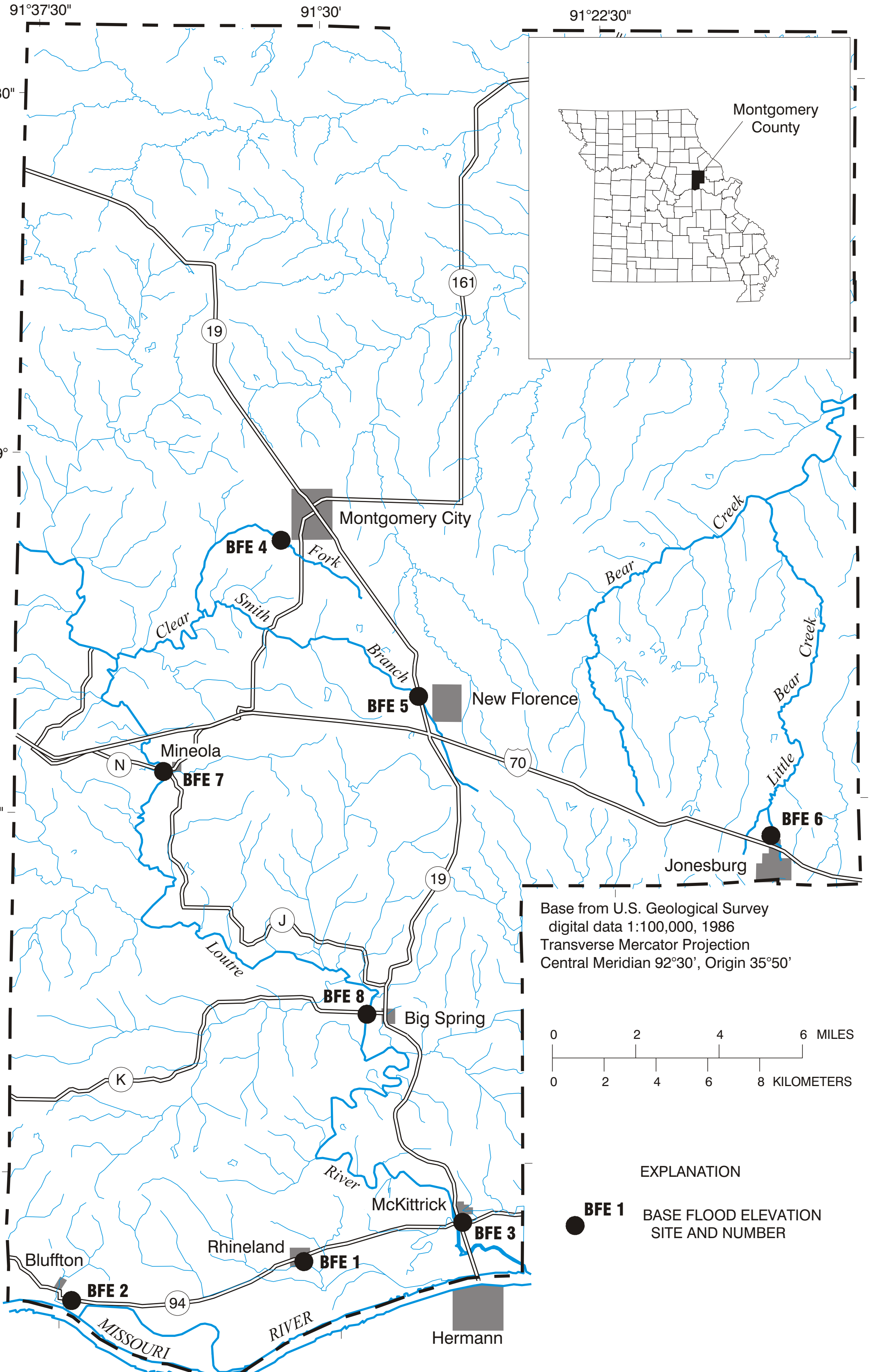


Figure 1. Location of base (100-year) flood elevation sites in Montgomery County, Missouri.

BFE 4 to 8 base (100-year) flood elevations. HEC-RAS is based on the principle of conservation of energy, which states that the energy at the upstream valley section is equal to the energy at the downstream section, plus the friction and transition losses between the two sections (one-dimensional). Starting water-surface elevations were verified by normal-depth computations at the farthest downstream valley section. Normal depth is the depth expected for a stream when the flow is uniform, steady, one-dimensional, and is not affected by downstream obstructions or flow changes (U.S. Department of Housing and Urban Development, 1995).

The hydraulic analyses for this study are based on unobstructed flow conditions. Computed base (100-year) flood elevations are valid only if hydraulic structures remain unobstructed and channel and overbank flow conditions remain essentially unchanged. Elevations are referenced to the National Geodetic Vertical Datum of 1929, and are called "above sea level" in this report. Elevation, locations, and descriptions of the bench and reference marks are given in table 1, at the back of this report.

Base Flood Elevations for Sites BFE 1 to 3

Sites BFE 1 to 3 are located along the Missouri River floodplain, at the towns of Rhineland, Bluffton, and McKittrick (fig. 2). The floodplain ranges from about 1.8 to 2.1 miles wide and the drainage area is approximately 524,000 square miles. The State Highway 19 embankment is immediately upstream from site BFE 3 and forms a constriction across the Missouri River floodplain (fig. 2); other possible constrictions in the study reach are the main channel levees on each bank of the Missouri River. These levees form an obstruction to flow across the floodplain as the Missouri River flows from the north edge of the floodplain at site BFE 2, to the south edge of the floodplain at the confluence of the Gasconade River. These types of constrictions are known to have a substantial impact on lateral and longitudinal water-surface elevations along the Missouri River floodplain (Southard, 1997).

Following the 1993 Missouri River flood, which destroyed the State Highway 19 crossing at McKittrick, the Missouri Department of Transportation requested the USGS to perform a floodway analysis of the Missouri River in the vicinity of Highway 19 using FESWMS. The study reach for the analysis, which included current-study sites BFE 1 and 3, began just below the mouth of the Gasconade River. To include site BFE 2 in the FESWMS model, additional valley and channel cross sections were surveyed upstream from Rhineland (BFE 1). Also, 7.5-minute topographic maps were used to supplement field-surveyed cross sections. Manning's roughness coefficients used in the analyses were determined from field observations of the stream and floodplain (Arcement and Schneider, 1989). Roughness values for the main channel ranged from 0.024 to 0.038, floodplain values ranged from 0.024 to 0.032, and woods and levees values ranged from 0.030 to 0.180. The model starting water-surface elevation was determined by convergence of the water-surface profile downstream of McKittrick (BFE 3), and by simulating the 1993 high-water profile. The FESWMS model results for the 100-year flood peak of 620,000 cubic feet per second are shown in figure 2 as surface-water contours. The ends of the contours are connected by straight lines that approximate the boundary of the model grid. The base (100-year) flood elevations for sites BFE 1 to 3 are 521.5, 527.2, and 516.0 feet above sea level (table 2).

Base Flood Elevation for Site BFE 4

Site 4 on Clear Fork, a tributary to Loutre River, is located approximately 1.2 miles southwest of Montgomery City, near the central part of Montgomery County (fig. 3). Clear Fork flows in a southeast to northwest direction at site BFE 4, with no bridges or other structures to constrict flow across the floodplain. Clear Fork has an average channel-top width of 40 feet and an average channel depth of 6 feet in the study reach. Upstream from site 4, the majority of the drainage area is farmland (rural); however, a part of the basin drains the southern one-half of south Montgomery City. The 100-year recurrence-interval regression equation for urban basins from Becker (1986) resulted in a base (100-year) flood discharge of 2,790 cubic feet per second for site BFE 4 (table 2).

Three valley and channel cross sections were obtained by field (transit-stadia) surveys at or near BFE 4 (fig. 3) and aligned perpendicular to the assumed direction of flow. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.050 to 0.055 for the main channel and from 0.065 to 0.200 for the floodplain. The starting water-surface elevation was determined by normal-depth computations and from HEC-RAS convergence analyses. The resulting base

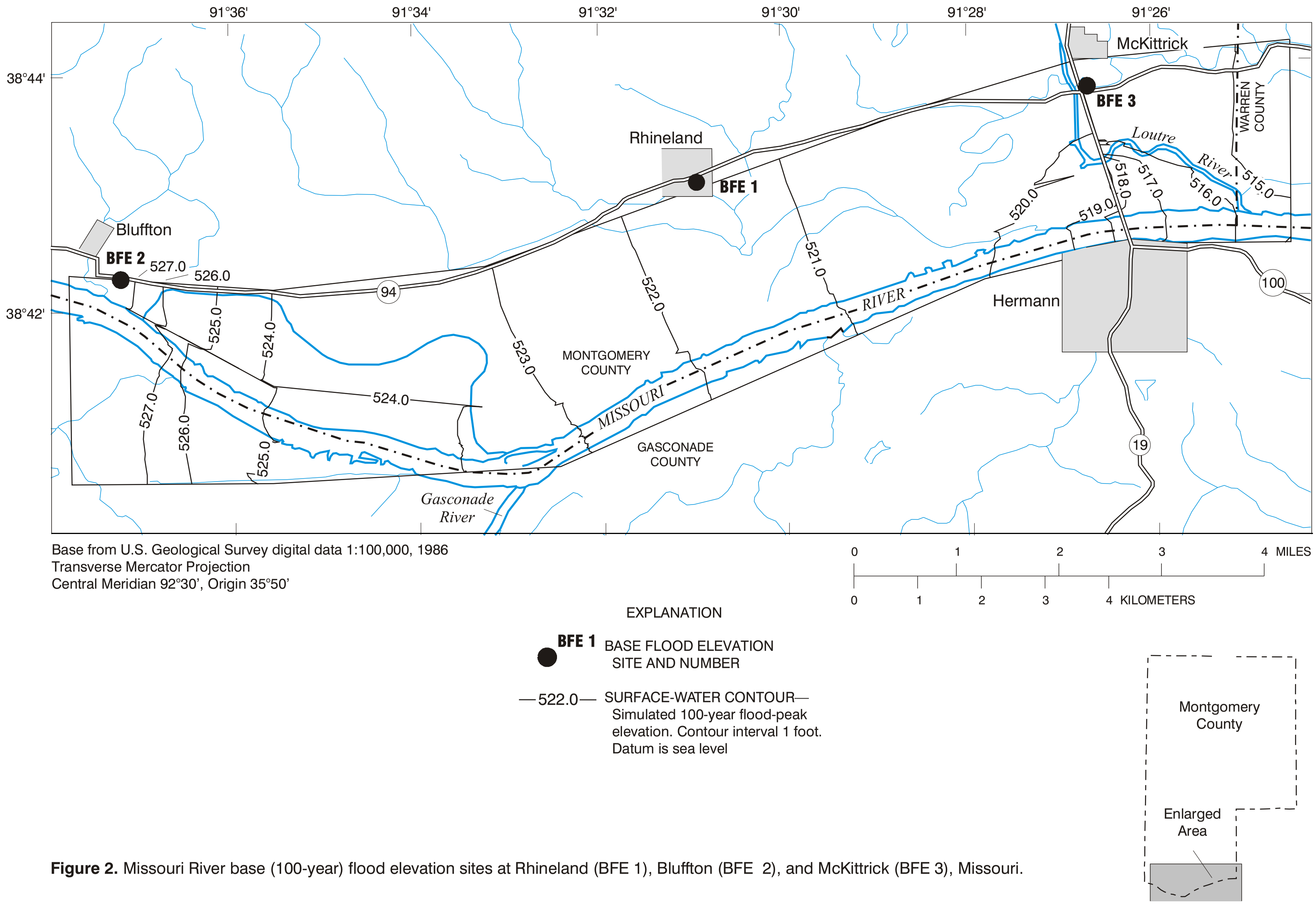


Figure 2. Missouri River base (100-year) flood elevation sites at Rhineland (BFE 1), Bluffton (BFE 2), and McKittrick (BFE 3), Missouri.

Table 2. Summary of base (100-year) flood discharges and elevations for selected sites in Montgomery County, Missouri

[mi^2, square mile; ft/mi, foot per mile; ft^3/s, cubic foot per second; ft, foot; --, not applicable]

Map no. (fig. 1)	Stream and location	Drainage area (A) (mi^2)	Main-channel slope (S) (ft/mi)	Impervious area (I), in percent	Base (100-year) flood discharge (ft^3/s)	Base (100-year) flood elevation[e] (ft)
BFE 1	Missouri River at Rhineland, Mo.	[a]524,000	--	--	[b]620,000	521.5
BFE 2	Missouri River at Bluffton, Mo.	[a]524,000	--	--	[b]620,000	527.2
BFE 3	Missouri River at McKittrick, Mo.	[a]524,000	--	--	[b]620,000	516.0
BFE 4	Clear Fork approximately 1.2 miles southwest of Montgomery City, Mo.	2.79	--	4	[c]2,790	766.0
BFE 5	Smith Branch approximately 0.5 mile west of New Florence, Mo.	1.56	--	2	[c]1,570	826.5
BFE 6	Little Bear Creek approximately 0.3 mile north of Jonesburg, Mo. at sewage disposal lagoon	.57	--	10	[c]865	851.7
BFE 7	Loutre River at State Highway N at west edge of Mineola, Mo.	201	9.27	--	[d]32,700	568.6
BFE 8	Loutre River approximately 0.5 mile west of Big Spring, Mo.	331	6.35	--	[d]40,700	535.6

[a] Approximately.
[b] U.S. Army Corps of Engineers (M. Vanderpool, written commun., 1997).
[c] Becker (1986), $Q_{100} = 986 (A)^{0.821} (I)^{0.144}$.
[d] Alexander and Wilson (1995), $Q_{100} = 170 (A)^{0.794} (S)^{0.471}$, Region II.
[e] Above sea level.

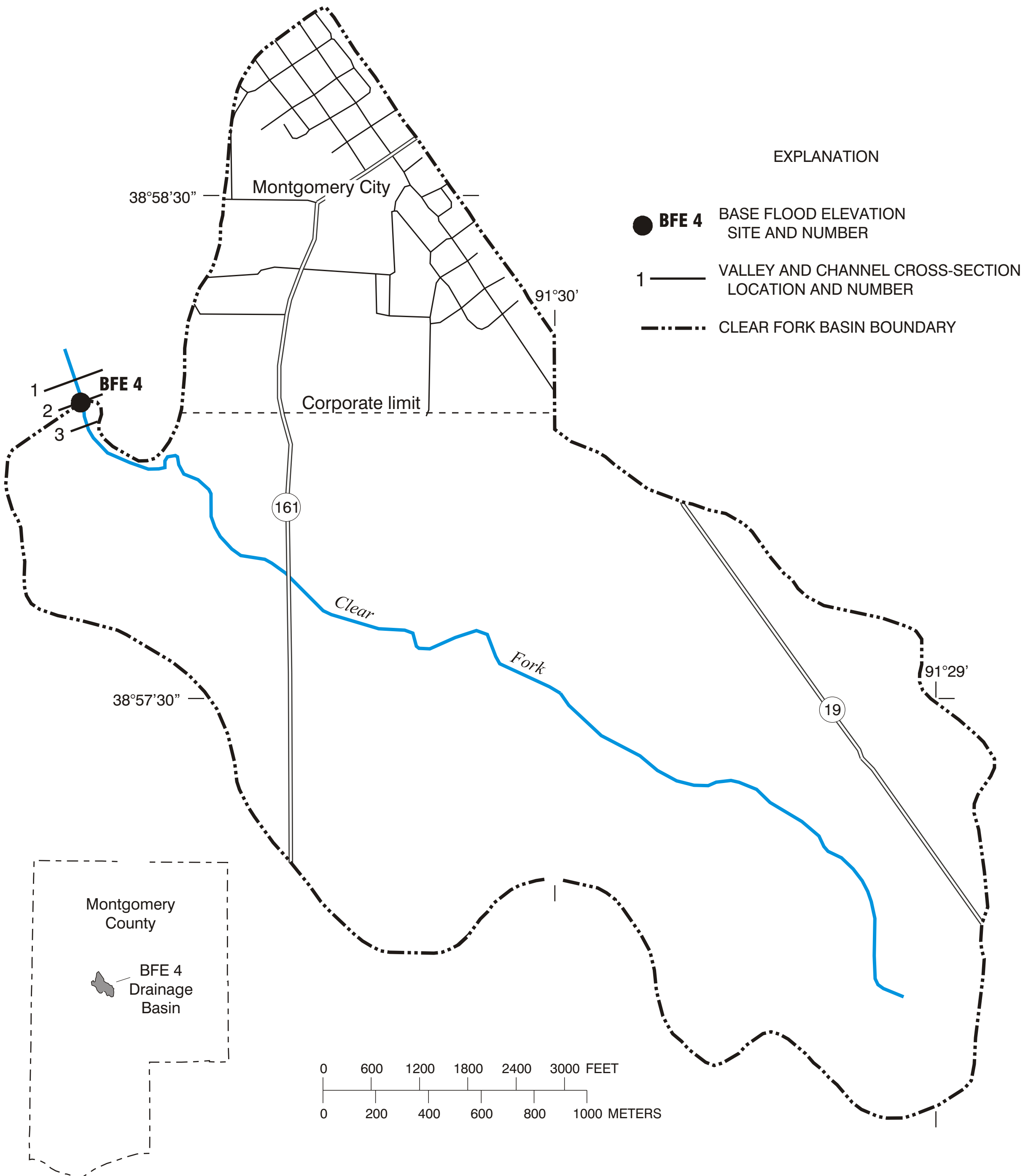


Figure 3. Clear Fork base (100-year) flood elevation site (BFE 4) at Montgomery City, Missouri.

(100-year) flood elevation for site BFE 4 is 766.0 feet above sea level (table 2).

Base Flood Elevation for Site BFE 5

Site 5 on Smith Branch, a tributary to Clear Fork, is located approximately 0.5 mile west of New Florence, near the central part of Montgomery County (fig. 4). Smith Branch flows through a concrete culvert at a gravel road crossing west of State Highway 19. The channel bends sharply to the left immediately downstream of the culvert, then flows west a short distance before bending right and flowing north. Within the study reach, Smith Branch has an average channel-top width of about 25 feet, and an average depth of about 5 feet. The drainage basin upstream from site 5 is partially urbanized with Smith Branch draining the southwest part of New Florence. The 100-year recurrence-interval regression equation for urban basins from Becker (1986) resulted in a base (100-year) flood discharge of 1,570 cubic feet per second for site BFE 5 (table 2).

Four valley and channel cross sections were obtained by field (transit-stadia) surveys at or near the BFE 5 location (fig. 4); the cross sections were surveyed perpendicular to the assumed direction of flow. Also, 7.5-minute topographic maps were used to laterally extend some of the overbank sections. Manning's roughness coefficients used in the analysis were determined from field observations (Arcement and Schneider, 1989). Coefficients ranged from 0.037 to 0.050 for the main channel and from 0.050 to 0.250 for the floodplain. The starting water-surface elevation was determined by normal-depth computations and from the HEC-RAS convergence analyses. The resulting base (100-year) flood elevation for site BFE 5 is 826.5 feet above sea level (table 2).

Base Flood Elevation for Site BFE 6

Site 6 on Little Bear Creek, a tributary to Bear Creek, is located approximately 0.3 mile north of Jonesburg, Missouri (fig. 5). East of Little Bear Creek channel is the Jonesburg sewage lagoon and west of the channel is a mixture of woods and pasture. No roads or constrictions are located across the floodplain with the exception of the lagoon. In the study reach, Little Bear Creek has an average channel-top width of 25 feet, and an average channel depth of 3 feet. Little Bear Creek drains a large part of Jonesburg. The 100-year recurrence interval regression equation for urban basins from Becker (1986) resulted in a base (100-year) flood discharge of 865 cubic feet per second for site BFE 6 (table 2).

Six valley and channel cross sections were obtained by field (transit-stadia) surveys at the BFE 6 location (fig. 5); the cross sections were surveyed perpendicular to the assumed direction of flow. Manning's roughness coefficients used in the analyses were determined from field observations of the stream and floodplain (Arcement and Schneider, 1989). Coefficients ranged from 0.050 to 0.055 for the main channel and from 0.075 to 0.150 for the floodplain. The starting water-surface elevation was determined by normal-depth computations and from HEC-RAS convergence analyses. Model results indicated a small part of the flood discharge (45 cubic feet per second) would flow to the east of the lagoon where the floodplain is substantially lower than the lagoon embankment. The resulting base (100-year) flood elevation for site BFE 6 is 851.7 feet above sea level (table 2).

Base Flood Elevation for Site BFE 7

Site 7 on Loutre River, a tributary to Missouri River, is located on State Highway N at the west edge of Mineola, Missouri in Montgomery County (fig. 6). Loutre River has an average channel-top width of 135 feet and an average channel depth of 17 feet in the study reach. The 100-year recurrence-interval regression equation for rural basins from Alexander and Wilson (1995) resulted in a base (100-year) flood discharge of 32,700 cubic feet per second for site BFE 7 (table 2).

Eight valley and channel cross sections were obtained by field (transit-stadia) surveys at or near the BFE 7 location (fig. 6), with 7.5-minute topographic maps used to supplement the field surveyed sections. During the field survey, a main-channel cross section of Loutre River was defined along the downstream side of the State Highway N bridge. Pertinent bridge and embankment geometry data for the piers, wingwalls, abutment/embankment slopes, and road profile were obtained at the time of the field survey. Also, pertinent geometry data for the two relief bridges west of the Loutre River main channel bridge were collected. Manning's roughness coefficients used in the analyses were determined from field observations of the stream and floodplain (Arcement and Schneider, 1989). Coefficients ranged from 0.042 to 0.050 for the main channel and from 0.055 to 0.150 for the floodplain. An areal comparison of drainage area and 1993 peak dis

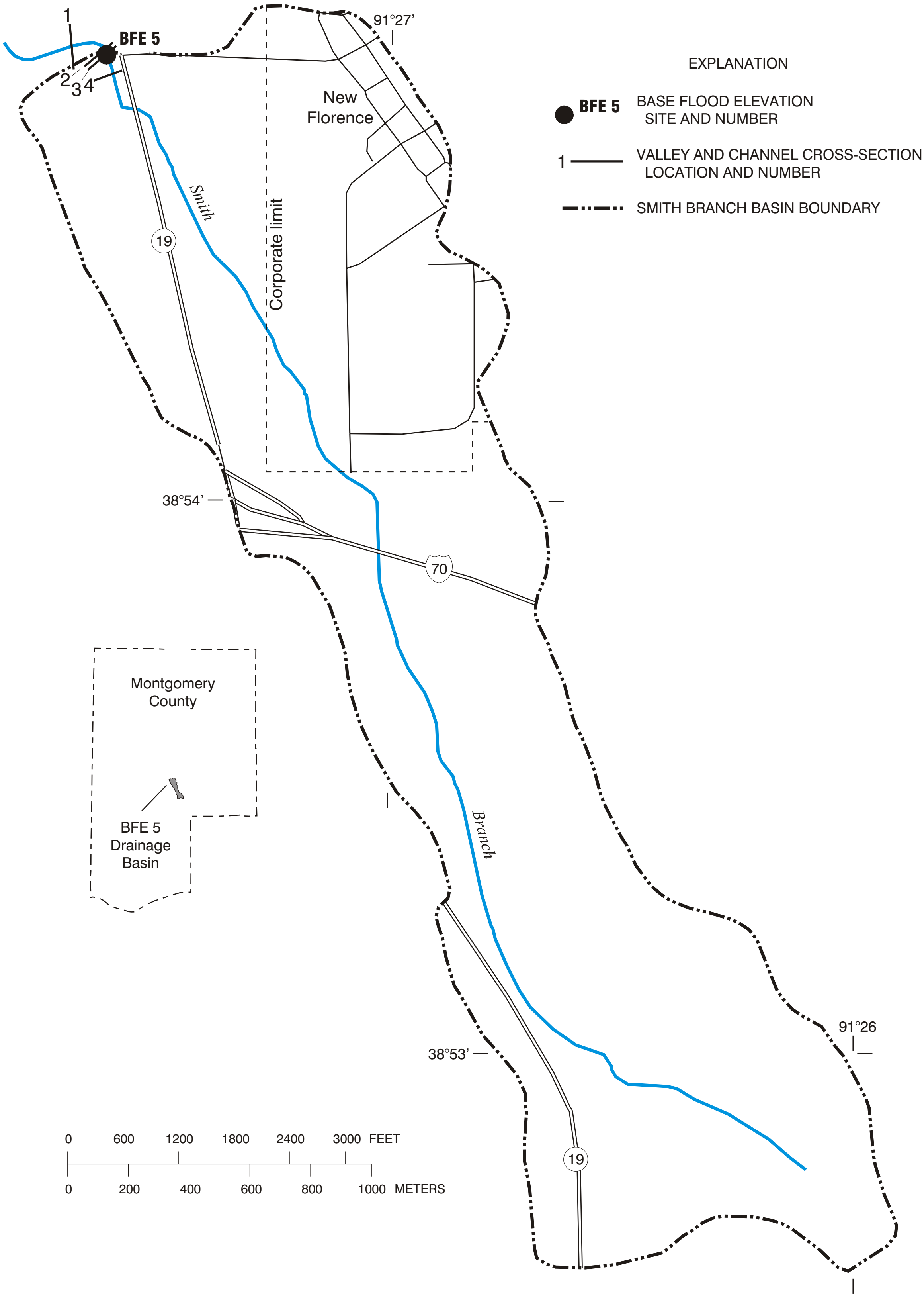


Figure 4. Smith Branch base (100-year) flood elevation site (BFE 5) at New Florence, Missouri.

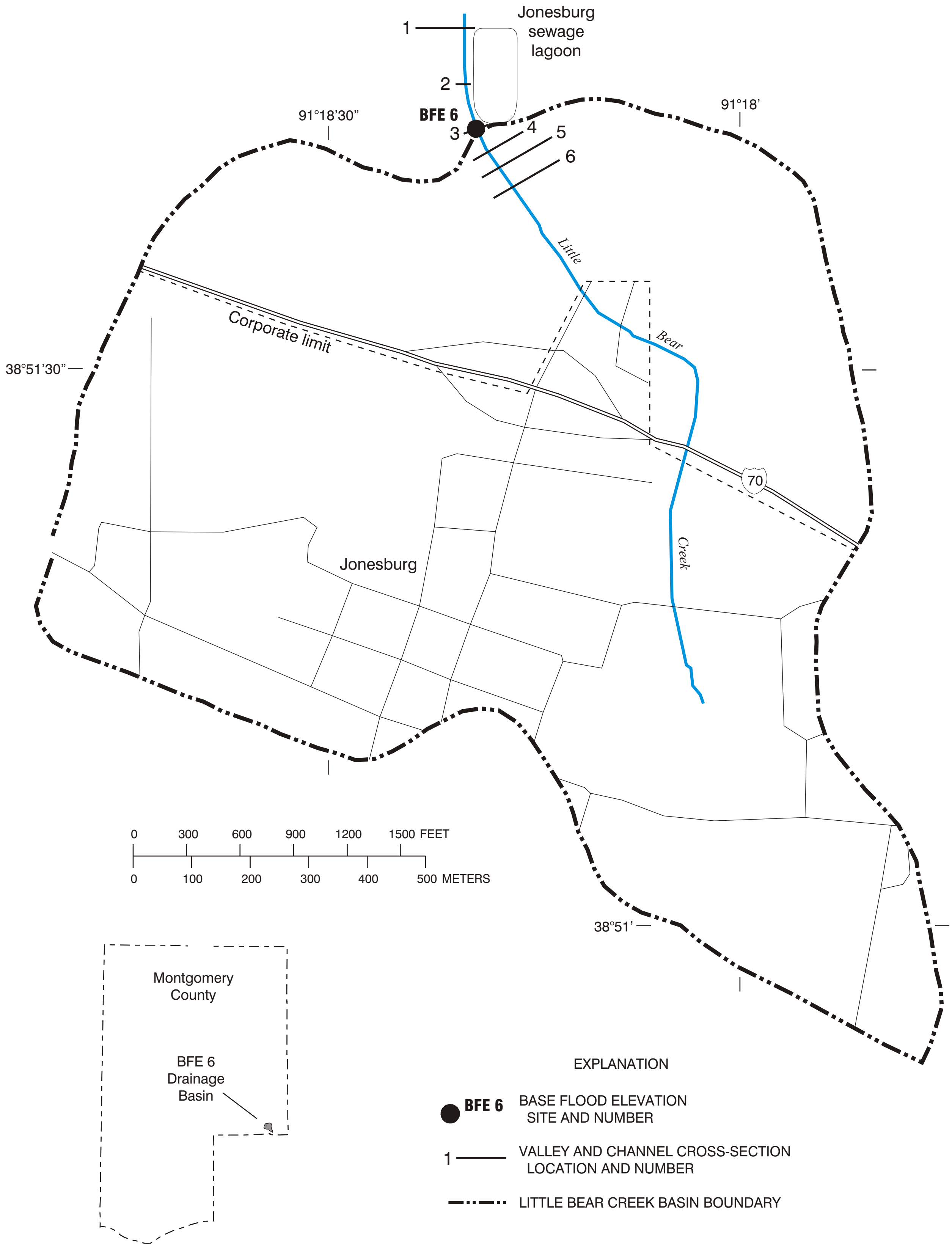


Figure 5. Little Bear Creek base (100-year) flood elevation site (BFE 6) at Jonesburg, Missouri.

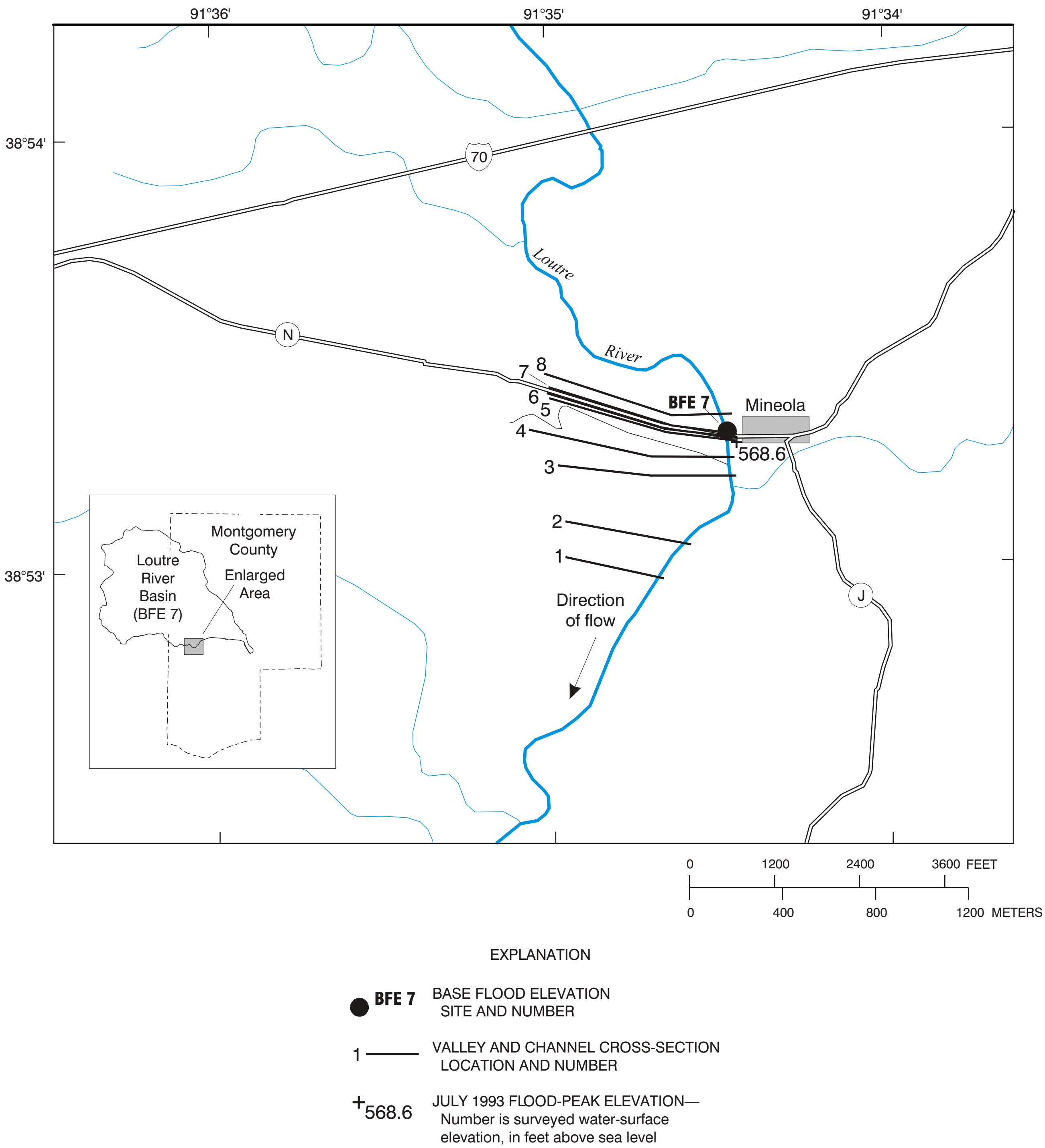
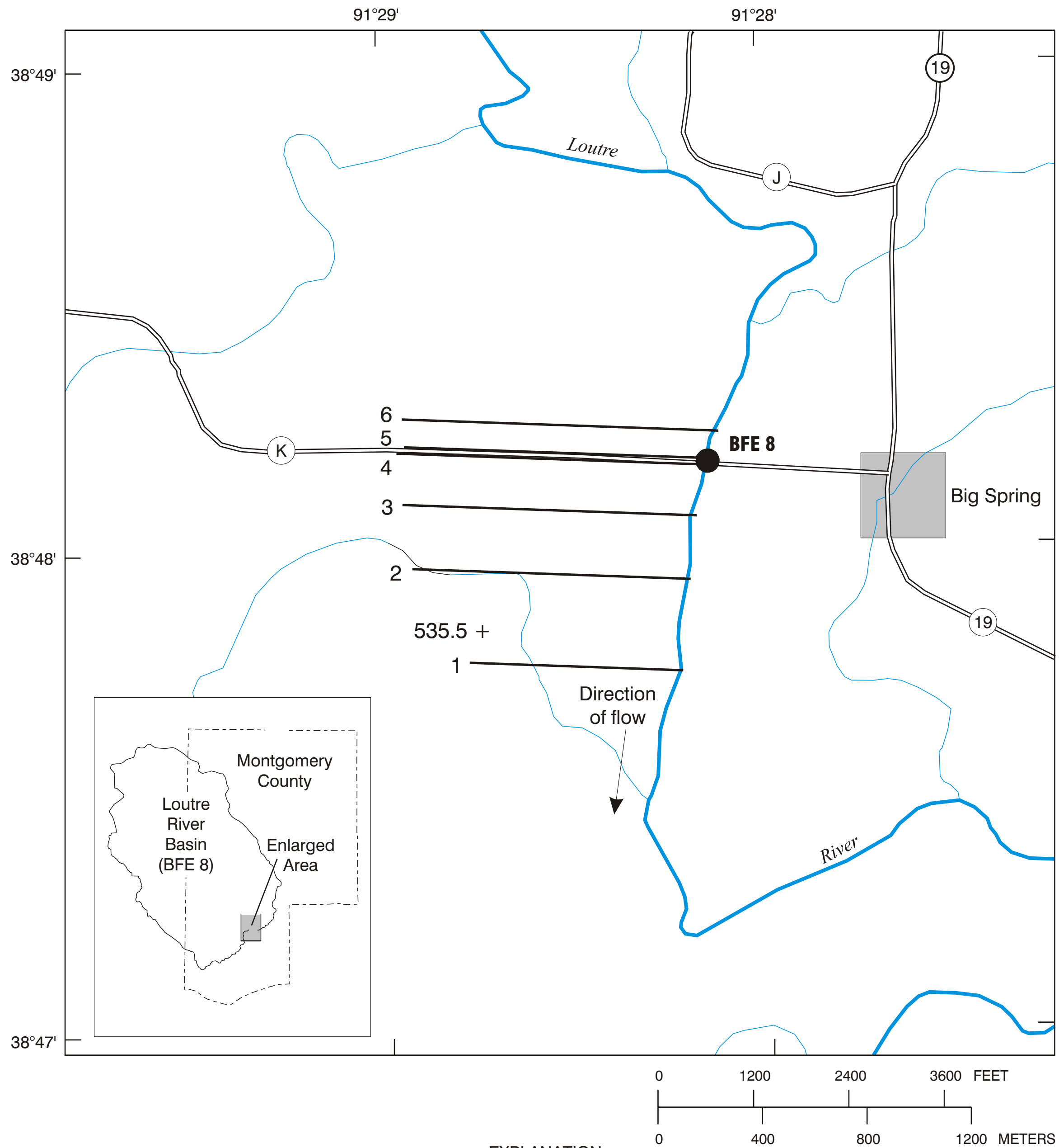


Figure 6. Loutre River base (100-year) flood elevation site (BFE 7) at Mineola, Missouri.



EXPLANATION

● **BFE 8** BASE FLOOD ELEVATION SITE AND NUMBER

1 ——— VALLEY AND CHANNEL CROSS-SECTION LOCATION AND NUMBER

+535.5 JULY 1993 FLOOD-PEAK ELEVATION—Number is surveyed water-surface elevation, in feet above sea level

Figure 7. Loutre River base (100-year) flood elevation site (BFE 8) at Big Spring, Missouri.

charges (U.S. Geological Survey streamflow-gaging station data) indicates the Loutre River at Mineola peak discharge of July 1993 was approximately equal to the base (100-year) discharge for the BFE 7 site. For this study, the 1993 flood-peak elevation of 568.6 feet above sea level (fig. 6) was used to determine the starting water-surface elevation for the HEC-RAS analyses. The resulting base (100-year) flood elevation for site BFE 7 is 568.6 feet above sea level (table 2).

Base Flood Elevation for Site BFE 8

Site 8 on Loutre River, a tributary to Missouri River, is located on State Highway K approximately 0.5 mile west of the town of Big Spring, Missouri in the southeast part of Montgomery County (fig. 7). Loutre River has an average channel-top width of about 140 feet and an average channel depth of about 15 feet in the study reach. The 100-year recurrence-interval regression equation for rural basins from Alexander and Wilson (1995) resulted in a base (100-year) flood discharge of 40,700 cubic feet per second for site BFE 8 (table 2).

Six valley and channel cross sections were obtained by field (transit-stadia) surveys in the vicinity of State Highway K bridge (fig. 7); 7.5-minute topographic maps were used to supplement the field-surveyed cross sections. The geometry of the existing State Highway K bridge cross section was defined along the downstream side. Pertinent bridge and embankment geometry data of the piers, wingwalls, abutment/embankment slopes, road profile, and other hydraulic features were measured or obtained during the field survey. Manning's roughness coefficients used in the analyses were determined from field observations of the stream and floodplain (Arcement and Schneider, 1989). Coefficients ranged from 0.042 to 0.050 for the main channel and from 0.055 to 0.200 for the floodplain. An areal comparison of drainage area and 1993 peak discharges (U.S. Geological Survey streamflow-gaging station data) indicates the Loutre River at Big Spring peak discharge of July 1993 was approximately equal to the base (100-year) discharge for the BFE 8 site. For this study, the 1993 flood-peak elevation of 535.5 feet above sea level (fig. 7) was used to determine the starting water-surface elevation for the HEC-RAS analyses. The resulting base (100-year) flood elevation for site BFE 8 is 535.6 feet above sea level (table 2).

SUMMARY

The primary requirement for community participation in the National Flood Insurance Program is the adoption and enforcement of floodplain management requirements. The purpose of the requirements is to minimize the potential for flood damages to existing and proposed development in flood-hazard areas. The U.S. Geological Survey, in cooperation with the State Emergency Management Agency, has completed a study using one- and two- dimensional surface-water flow models to compute base (100-year) flood elevations for selected communities in Missouri. This report provides base (100-year) flood elevations for eight flood-hazard areas designated by the Federal Emergency Management Agency as approximate Zone A areas in Montgomery County, Missouri.

The two-dimensional finite-element surface-water flow-modeling system, FESWMS, was used to compute the base (100-year) flood elevations for Zone A sites on the Missouri River at Rhineland (BFE 1), Bluffton (BFE 2), and McKittrick (BFE 3), Missouri. The FESWMS model was used to simulate variations in water-surface elevations laterally and longitudinally across the Missouri River floodplain because of levees and road crossings. The resulting Missouri River base (100-year) flood elevations for sites BFE 1 to 3 are 521.5, 527.2, and 516.0 feet above sea level.

The one-dimensional surface-water flow model, HEC-RAS, was used to compute the base flood elevations for Zone A sites outside the Missouri River floodplain and within Montgomery County. The base (100-year) flood elevations for the three urbanized Zone A sites of Clear Fork near Montgomery City (BFE 4), Smith Branch at New Florence (BFE 5), and Little Bear Creek at Jonesburg (BFE 6), Missouri are 766.0, 826.5, and 851.7 feet above sea level. The two rural Zone A sites on the Loutre River have base (100-year) flood elevations at Mineola (BFE 7) and Big Spring (BFE 8) of 568.6 and 535.6 feet above sea level.

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SUPPLEMENTAL DATA

Table 1. Bench and reference mark elevations and locations for selected sites in Montgomery County, Missouri

[ft, feet]

Bench or reference mark number	Bench or reference mark elevation[1] (ft)	Description of location
RM—BFE 1	516.86	Standard tablet stamped “16PGH1972” set in the center of south headwall of culvert, about 53 feet south and 52 feet east and 1.4 feet higher than centerline of T-road west, at Rhineland.
RM—BFE 2	524.25	Cut square on top of southeast wingwall of Katy Trail bridge over Synthianna Creek, at Bluffton.
RM—BFE 3	522.00	Cut square on top of southeast corner of concrete curb of State Highway 94 bridge over Loutre River, at McKittrick.
BM—BFE 4	821.91	Cut square on top of concrete end of metal pipe culvert, about 78 feet south and 25 feet east of State Highway 19 at State Highway B west, at Montgomery City.
RM—BFE 4	773.94	Top of northeast corner of concrete roof of outlet structure of currently (1998) unused Montgomery City sewage lagoon, near Montgomery City.
BM—BFE 5	850.46	Standard tablet stamped “B1481935” set in top of concrete wingwall at the southeast corner of State Highway 19 underpass, 1.2 miles west along railroad from the station at New Florence.
RM—BFE 5	825.47	Top of northeast corner of concrete wingwall of Picnic Street culvert over Smith Branch, about 150 feet west of centerline State Highway 19, at New Florence.
BM—BFE 6	893.21	Cut square on northwest concrete wingwall of Interstate 70 overpass, about 0.5 mile north of Jonesburg.
RM—BFE 6	851.75	Three-inch lag bolt in power pole about 1-foot above ground elevation, at the southeast corner of Jonesburg sewage-treatment lagoon, just north of Jonesburg.
BM—BFE 7	562.91	U.S. Geological Survey gaging station bronze tablet set in top of southwest pier cap of State Highway N bridge over Loutre River, at west edge of Mineola.
BM—BFE 8	544.33	Cut square on top of west headwall of culvert of State Highway 19, about 500 feet south of State Highway K, at Big Spring.
RM—BFE 8	541.82	Top southeast corner of southeast concrete abutment of State Highway K bridge over Loutre River, approximately 0.5 mile west of Big Spring.

[1]Above sea level.