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ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT

SIMULATIONS OF FLOODFLOWS ON THE WHITE RIVER IN THE VICINITY OF U.S. HIGHWAY 79 NEAR CLARENDON, ARKANSAS

Water-Resources Investigations Report 02-4256

U.S. Department of the Interior
U.S. Geological Survey

A

B

C

Photographs on Front Cover:

A - Tugboat pushing a barge on the White River 1/4 mile upstream from the U.S. Highway 79 crossing.

B - Vehicle traffic on the U.S. Highway 79 White River bridge.

C - Roc Roe Bayou, 1/2 mile upstream from the confluence of the White River.

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By Jaysson E. Funkhouser and C. Shane Barks

U.S. GEOLOGICAL SURVEY
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Little Rock, Arkansas
2003

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For additional information
write to:

District Chief
U.S. Geological Survey, WRD
401 Hardin Road
Little Rock, Arkansas 72211

Copies of this report can be
purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver Federal Center
Denver, Colorado 80225

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per day (ft/d)	0.3048	meter per day (m/d)
square foot per second (ft^2/s)	0.0929	square meter per second (m^2/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

In this report vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929).

SIMULATIONS OF FLOODFLOWS ON THE WHITE RIVER IN THE VICINITY OF U.S. HIGHWAY 79 NEAR CLARENDON, ARKANSAS

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ABSTRACT

A two-dimensional finite-element surface-water model was used to study the effects of the proposed modification to the U.S. Highway 79 corridor on flooding on the White River near Clarendon, Arkansas. The effects of floodflows were simulated for the following scenarios: existing, natural, and four proposed bridging alternatives. All of the scenarios were modeled with floods having the 5- and 100-year recurrence intervals (115,100 and 216,000 cubic feet per second). The simulated existing conditions included a 3,200-foot White River bridge located on the east side of the study area near Clarendon, Arkansas; a 3,700-foot First Old River bridge located 0.5 mile west of the White River bridge opening; and a 1,430-foot Roc Roe Bayou bridge located 1.6 mile west of the First Old River bridge. The simulated hypothetical natural conditions involved removing the U.S. Highway 79 and the Union Pacific Railroad embankments along the entire length of the flood plain. The primary purpose of model simulations for natural conditions was to calculate backwater data for the existing and proposed conditions. The four simulated hypothetical proposed alternatives involved a 1.8-mile White River bridge located on the east side of the study area near Clarendon, Arkansas, either a 1,400-foot relief bridge (Alternative 1) or a 1,545 relief bridge (Alternatives 2-4) located 0.25 mile west of the White River bridge opening, and three different Roc Roe Bayou bridge openings ranging from 1,540-3,475 feet in length located 0.9 mile west of the relief bridge (Alternatives 1-4).

Simulation of the 5-year floodflow for the existing bridge openings indicates that about 57 percent (65,600 cubic feet per second) of flow was conveyed by the White River bridge, about 26 percent (29,900 cubic feet per second) by the First Old River bridge, and about 17 percent (19,600 cubic feet per second) by the Roc Roe Bayou bridge. Maximum depth-averaged point velocities for the White River, First Old River, and Roc Roe Bayou bridges were 3.6, 1.6, and 3.3 feet per second, respectively. For the 100-year floodflow, the simulation indicates that about 56 percent (123,100 cubic feet per second) of flow was conveyed by the White River bridge, about 26 percent (56,200 cubic feet per second) by the First Old River bridge, and about 19 percent (41,000 cubic feet per second) by the Roc Roe Bayou bridge. The maximum depth-averaged point velocities for the White River, First Old River, and Roc Roe Bayou bridges were 4.2, 2.2, and 4.1 feet per second, respectively.

Simulation of the 5-year floodflow for the proposed U.S. Highway 79 alignment alternatives indicates that 76-78 percent (87,100-89,900 cubic feet per second) of the flow was conveyed by the proposed White River bridge, 6-7 percent (7,000-7,500 cubic feet per second) by the proposed relief bridge, and 13-16 percent (14,600-18,600 cubic feet per second) by the proposed Roc Roe Bayou bridge. For the 100-year floodflow, simulations predicted that 70-72 percent (151,200-155,600 cubic feet per second) of the flow was conveyed by the proposed White River bridge, 9-10 percent (19,800-20,700 cubic feet per second) by the proposed relief bridge, and 14-20 percent (30,700-43,000 cubic feet per second) by the proposed Roc Roe Bayou bridge.

INTRODUCTION

The hydraulic performance of bridges during floods is a major concern when the opening and grade of drainage structures are designed. In the case of multiple bridge openings, it is important to know the distribution of discharge and velocity through the bridges for an efficient hydraulic design. U.S. Highway 79, which crosses the White River flood plain in southeastern Arkansas (fig. 1), is such a case.

U.S. Highway 79 is a two-lane highway constructed during the late 1920's and early 1930's. The town of Clarendon is on the east bank of the White River (fig. 2). Because of a substantial increase in traffic volume and the age and deterioration of the roadway, the Arkansas State Highway and Transportation Department (AHTD) made the decision to replace the roadway and bridges that cross the White River and its flood plain.

Two National Wildlife Refuges are located near the U.S. Highway 79 crossing of the White River. The Cache River National Wildlife Refuge is located to the north and the White River National Wildlife Refuge is located to the south (fig. 1). The AHTD and U.S. Fish and Wildlife Service (USFWS) are concerned about the effects that velocities and velocity distributions generated by the proposed bridges will have on the environment. To deal with these concerns, the AHTD proposed combining the two bridges that cross the White River and the First Old River, adding a relief bridge in the White River flood plain, and lengthening the bridge that crosses Roc Roe Bayou by 110 ft (fig. 2). In addition, the AHTD and USFWS also are concerned about potential high point velocities in the Roc Roe Bayou bridge opening and any possibility for scour near bridge abutments.

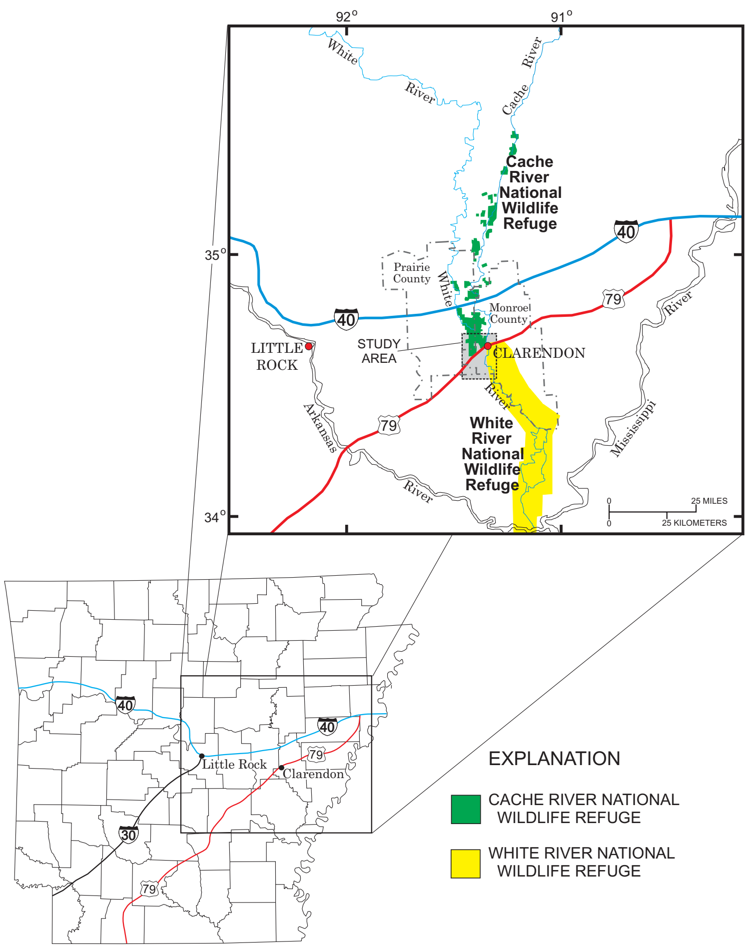

Figure 1. Location of study area.

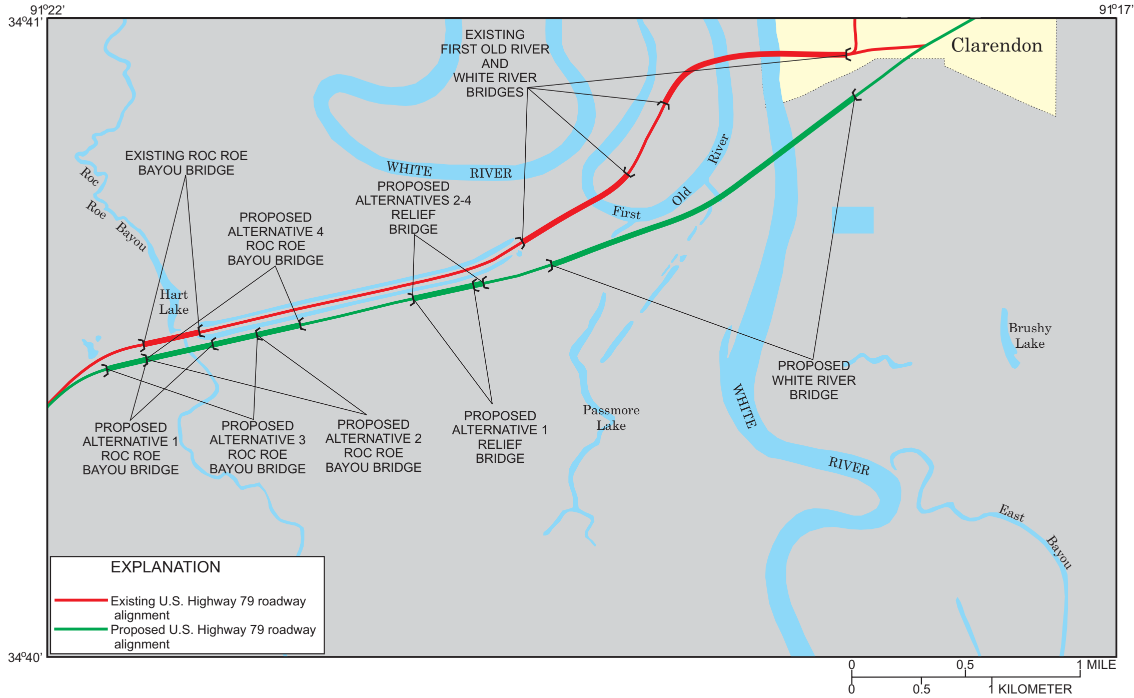

Figure 2. Location of existing and proposed roadway alignments.

A large portion of the White River breaches its banks and flows along its flood plain during flood events. The U.S. Army Corps of Engineers (USACE) computed a discharge of 439,648 ft^3/s at the streamgage on the White River at Clarendon during a major flood event in April 1927. Of the total discharge, 130,088 ft^3/s flowed through the main channel of the White River and 309,560 ft^3/s flowed through the relief bridges (U.S. Army Corps of Engineers, written commun., 1927). Because of the complexity of the site and the two-dimensional nature of the flow, a two-dimensional flood study was needed to accurately describe the discharge distribution, velocity, and velocity distribution through the White River bridge openings. To address this need, the U.S. Geological Survey (USGS), in cooperation with the AHTD, conducted simulations of floodflows of the White River in the vicinity of U.S. Highway 79 near Clarendon, Arkansas.

Purpose and Scope

The purpose of this report is to present the results of floodflow simulations from a two-dimensional surface-water model. These simulations illustrate the hydraulic effects that the proposed bridges will have on the White River flood plain in the vicinity of Clarendon, Arkansas. The simulation results will aid the AHTD in the design of U.S. Highway 79 bridges crossing the White River flood plain.

This report presents results of a two-dimensional surface-water model for floodflows having 5- and 100-year recurrence intervals for existing, natural, and proposed conditions. Discharge, discharge distribution, velocity, and velocity distribution are given for various locations of interest throughout the study area. Backwater data are given at the approach section approximately 1 mi upstream from U.S. Highway 79. Other topics discussed include the evaluation of hydrology, modeling approach, model description, model calibration, and simulation of floodflows.

Acknowledgments

The assistance of Henry Langston and the personnel of the Environmental Division of the AHTD is greatly appreciated. The assistance of Ms. Janice Fulford of the USGS, Office of Surface Water and Mr. Karl Winters of the USGS, Mississippi District were instrumental in the success of this project. Also, gratitude is expressed to the USFWS for granting the USGS access to the wildlife refuges for the flood plain survey.

DESCRIPTION OF STUDY AREA

The study area is located in eastern Prairie County and western Monroe County near Clarendon, Arkansas (fig 1). The White River drains 25,555 mi^2 (Sullavan, 1974) at the U.S. Highway 79 bridge. The USACE has operated a gaging station on the White River at Clarendon (gaging station 07077800) since 1927 and on the White River at Aberdeen (gaging station 07077810) since 1932. The gaging station at Clarendon is located on the Union Pacific Railroad bridge approximately 500 ft downstream from the U.S. Highway 79 White River bridge (fig. 3). The gaging station at Aberdeen is located on the right bank of the White River about 8 river mi downstream from the U.S. Highway 79 crossing.

The study area includes a 17-mi reach, a 1.5-mi reach, and a 9-mi reach of the White River, Cache River, and Roc Roe Bayou, respectively (fig. 3). The 17-mi reach of the White River consists of a 9-mi reach upstream from U.S. Highway 79 and a 8-mi reach downstream. The White River flood plain is approximately 5.5 mi wide in the northern part of the study area, 3.5 mi wide at the U.S. Highway 79 crossing, and approximately 4.5 mi wide in the southern part of the study area. The White River flows in a southeasterly direction, and the Cache River and Roc Roe Bayou flow in a southerly direction. The confluence of the Cache River with the White River is located approximately 1 mi upstream from the existing U.S. Highway 79 White River bridge. The confluence of Roc Roe Bayou with the White River is located approximately 7 mi downstream from the existing U.S. Highway 79 White River bridge.

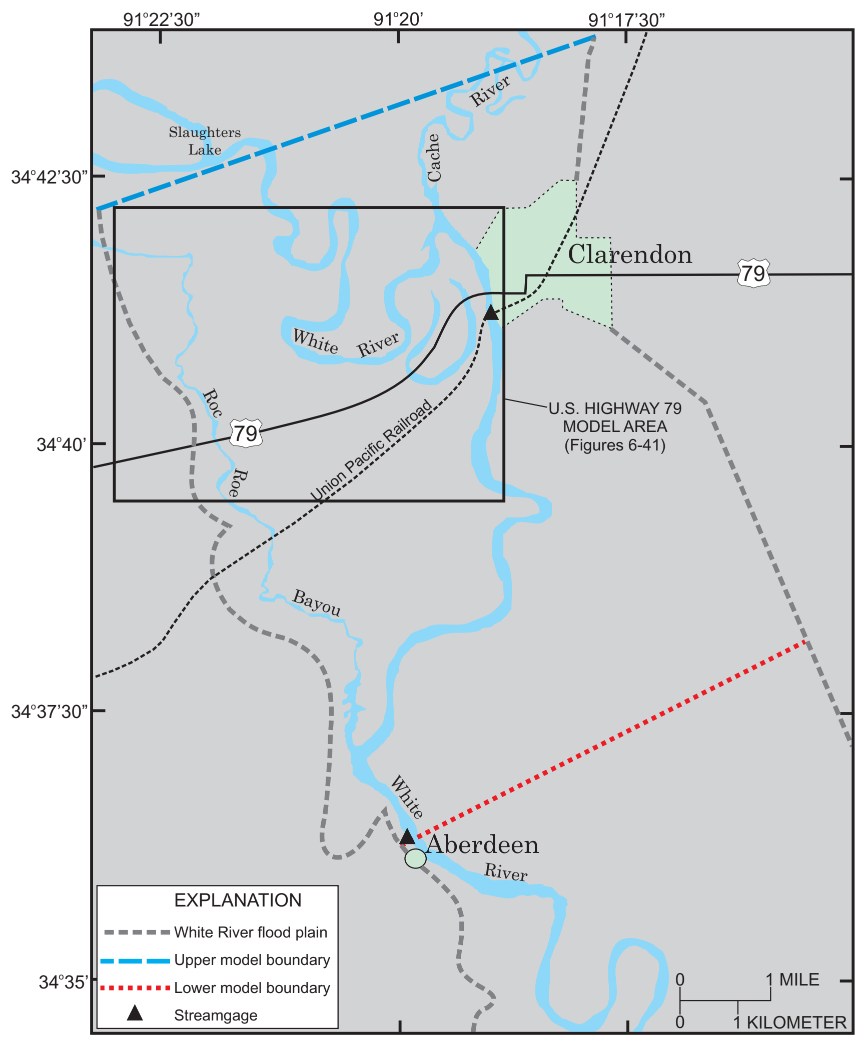

Figure 3. White River flood plain upper and lower model boundaries and U.S. Highway 79 model area in the study area.

The average slope of the basin in the study area is 0.36 ft/mi. The basin is mostly characterized as flat, swampy, and heavily wooded with dense vegetation throughout. However, 20 percent of the study area consists of cotton and rice fields. The basin includes numerous small, braided, meandering channels, many of which contain small beaver dams that make the channels ineffective for conveying flow. At the eastern boundary of the study area, the flood plain is open and is currently being used for row cropping, with a shallow sloping bank (less than 0.1 ft/ft). The western boundary is a combination of land used for row crops and land that is heavily wooded, with a steep sloping bank (greater than 2 ft/ft).

Floodflows for several scenarios were simulated in this report. The scenarios were existing conditions, natural conditions, and four proposed alternatives. Natural conditions and proposed conditions simulated hypothetical modifications to existing conditions.

Existing Conditions

U.S. Highway 79 uses three separate bridges to cross the White River flood plain-one 3,200-ft bridge over the White River near Clarendon, one 3,700-ft bridge over the First Old River located 0.5 mi west of the White River bridge opening, and one 1,430-ft bridge over Roc Roe Bayou located 1.6 mi west of the First Old River (fig. 2). The embankments between the bridges were constructed from soil material dug from the borrow pits that run adjacent to the embankments. These pits range in depth from 3 to 10 ft. Downstream from U.S. Highway 79, the Union Pacific Railroad crosses the White River flood plain with a series of five embankments and five bridges.

Natural Conditions

Natural conditions involved the hypothetical removal of all existing U.S. Highway 79 and Union Pacific Railroad embankments and bridges from the study area. Model simulations for natural conditions were run to aid in the calculation of the backwater caused by the existing and proposed U.S. Highway 79 roadway alignments.

Proposed Conditions

Proposed conditions involve the hypothetical construction of the bridges planned by the AHTD. The AHTD plans to construct a new roadway alignment for a 4.8-mi stretch of U.S. Highway 79 near Clarendon, Arkansas. The proposed new alignment will be located approximately 425 ft downstream from the existing highway (fig. 2). The AHTD has designed four alternate roadway alignments with varying bridge lengths (fig 2).

Alternative 1 (table 1) consists of three bridges: a 1.8-mi White River bridge, a 1,400-ft relief bridge located approximately 0.25 mi west of the White River bridge, and a 1,540-ft Roc Roe Bayou bridge crossing approximately 0.9 mi west of the relief bridge. Flood plain vegetation was added in areas upstream from, downstream from, and across the Roc Roe Bayou opening. Riprap was added to the west opening of the White River Bridge and both ends of the relief and Roc Roe Bayou bridge openings. The Union Pacific Railroad White River flood plain crossing was not altered for the proposed conditions.

Alternative 2 (table 1) consists of three bridges: a 1.8-mi White River bridge, a 1,545-ft relief bridge located approximately 0.25 mi west of the White River bridge, and a 2,475-ft Roc Roe Bayou bridge crossing approximately 0.9 mi west of the relief bridge. The additional 935 ft for the Roc Roe Bayou bridge crossing was added to the eastern end of the bridge. Flood plain vegetation was added in areas upstream from, downstream from, and across the Roc Roe Bayou opening. Riprap was added to the west opening of the White River bridge and to both ends of the relief and Roc Roe Bayou bridge openings. The Union Pacific Railroad White River flood plain crossing was not altered for the proposed conditions.

Alternative 3 (table 1) consists of three bridges: a 1.8-mi White River bridge, a 1,545-ft relief bridge located approximately 0.25 mi west of the White River bridge, and a 3,475-ft Roc Roe Bayou bridge crossing approximately 0.9 mi west of the relief bridge. The additional 1,935 ft for the Roc Roe Bayou bridge crossing was added the western (1,000 ft) and eastern (935 ft) ends of the bridge. Flood plain vegetation was added in areas upstream from, downstream from, and across the Roc Roe Bayou opening. Riprap was added to the west opening of the White River bridge and both ends of the relief and Roc Roe Bayou bridge openings. The Union Pacific Railroad White River flood plain crossing was not altered for the proposed conditions.

Table 1. Existing and alternative proposed bridge widths

[ft, feet; mi, mile, NA, not applicable]

	Existing	Alternative 1	Alternative 2	Alternative 3	Alternative 4
White River Bridge	3,200 ft	1.8 mi	1.8 mi	1.8 mi	1.8 mi
First Old River Bridge	3,700 ft	NA	NA	NA	NA
Relief Bridge	NA	1,400 ft	1,545 ft	1,545 ft	1,545 ft
Roc Roe Bayou Bridge	1,430 ft	1,540 ft	2,475 ft	3,475 ft	3,475 ft

Alternative 4 (table 1) consists of three bridges: a 1.8-mi White River bridge, a 1,545-ft relief bridge located approximately 0.25 mi west of the White River bridge, and a 3,475-ft Roc Roe Bayou bridge crossing approximately 0.9 mi west of the relief bridge. The additional 1,935 ft for the Roc Roe Bayou bridge crossing was added to the eastern end of the bridge. Flood plain vegetation was added in areas upstream from, downstream from, and across the Roc Roe Bayou opening. Riprap was added to the west opening of the White River Bridge and both ends of the relief and Roc Roe Bayou bridge openings. The Union Pacific Railroad White River flood plain crossing was not altered for the proposed conditions.

Hydrology

Flood frequencies in the White River Basin were estimated using techniques outlined by the Interagency Advisory Committee on Water Data (1982). Peak floodflows for floods having 5- and 100-year recurrence intervals were estimated for combined flooding on the White River and Roc Roe Bayou using the regulated period of record from 1973 to 1994 flow data collected from the USACE White River gaging station at Clarendon, Arkansas. During the time between the mid-1960’s to 1973, several dams were constructed on the upper White River Basin. The estimated 5- and 100-year floodflows at the White River gaging station are 115,100 ft^3/s and 216,000 ft^3/s, respectively. Because large flood magnitudes were simulated in this report, sustained peak discharges are probable. Therefore, steady-flow conditions were simulated.

MODELING APPROACH

Floodflow simulations for this report were based on a two-dimensional surface-water model. First, a computational grid representing the flow system for the existing conditions was constructed and appropriate boundary conditions and model parameters were selected. Next, the model was calibrated to existing conditions and a sensitivity analysis performed on selected model parameters. Finally, simulations were performed for the 5- and 100-year floodflows calibrated to existing conditions, then simulations for the natural conditions and the proposed conditions were performed.

The computational grid was constructed for the 33.5-mi^2 model area in the White River flood plain between the upper and lower model boundaries (fig. 3). The model area within the White River flood plain extends from about 2.7 mi upstream from the proposed U.S. Highway 79 roadway alignment. Simulation results from the model are presented in figures 6-41 for about a 13-mi^2 part of the model area, referred to as the U.S. Highway 79 model area in figure 3.

Model Description

The Finite-Element Surface-Water Modeling System for Two-Dimensional flow in a Horizontal Plane (FESWMS-2DH) (Froehlich, 1989) was selected as an appropriate model for simulating two-dimensional flows within the study area. The model uses the Galerkin finite-element method to solve three partial-differential equations representing conservation of mass and momentum (Lee and Froehlich, 1989). The model area is divided into triangular and quadrilateral sections (elements) of variable size, and input data are selected to describe the physical features of the model area. A depth-averaged velocity is computed at each computational point (node) in the model domain.

Input data requirements can be separated into three major categories:

1. Geographical information. Land-surface elevations for each element, and dimensions and locations of each element (as defined by the computational grid).

2. Boundary conditions. Water-surface elevation or flow conditions at the model boundaries; also any net inflows and outflows to each element. Appropriate boundary conditions are needed to implement an accurate model.

3. Model parameters. Resistance coefficients for each element, possibly as a variable function of depth or velocity; also kinematic eddy viscosity.

An explanation of the theory of the model is beyond the scope of this report; however, a detailed explanation of the theory is provided in the research report by Lee and Froehlich (1989).

Model Implementation

There are several steps involved in the implementation of FESWMS-2DH. First, a finite-element grid representing the flow system must be constructed and tested. Once a stable grid has been constructed, boundary conditions, such as water-surface elevation and flow, must be determined. Finally, several model parameters and options must be considered to determine which model will produce the most accurate results for floodflow simulations.

Computational Grid

The use of FESWMS-2DH requires that the model area be divided into elements that form a grid (fig. 4). In the case of a triangular and quadrilateral grid, nodes are located at the corners, mid-sides, and center of the elements and are assigned coordinates and elevations. A finite-element grid should be carefully designed so that mass is conserved within the system.

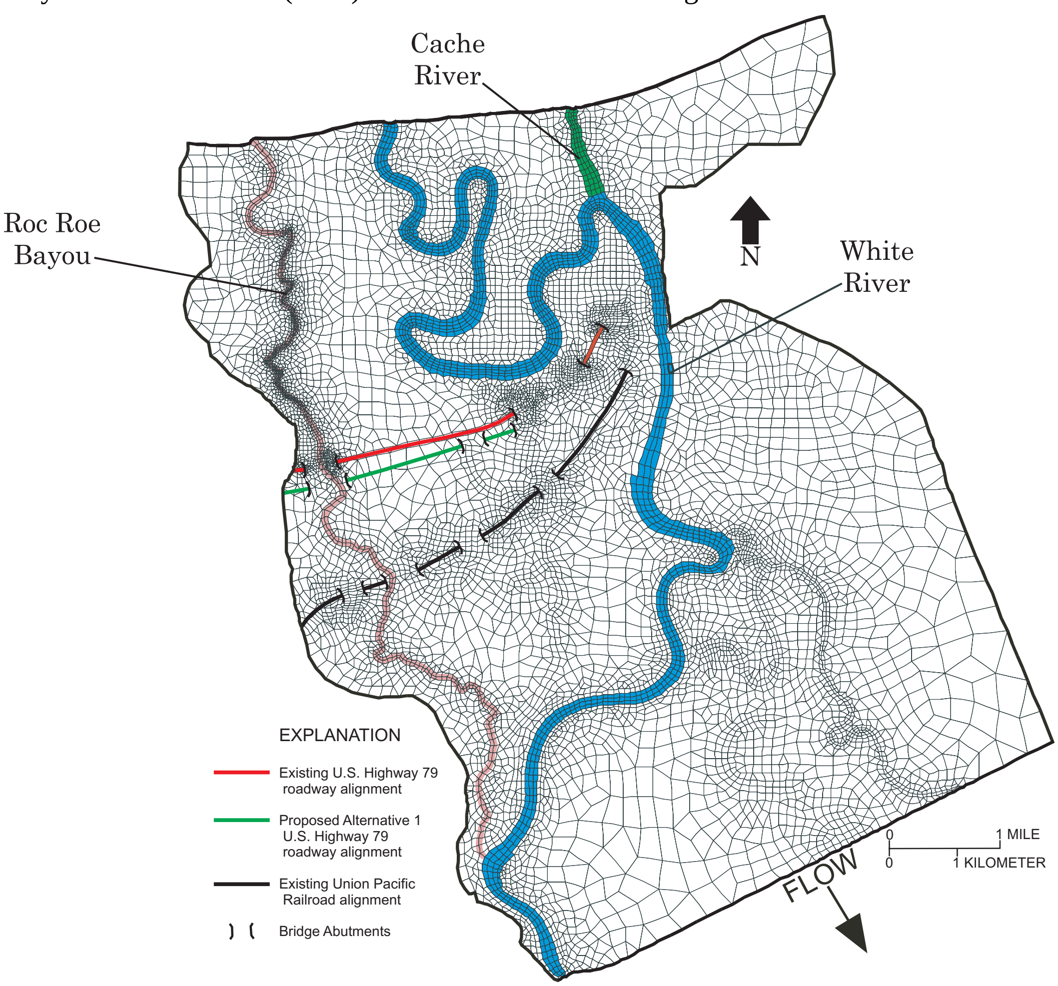

Figure 4. Computational grid generated for the model area.

The finite-element grid needs to be more refined (smaller elements) in areas where changes in velocity or bathymetry are substantial than in areas where changes are gradual. Because of the size of the grid needed for this report, the model did not fully conserve the mass (discharge) within the system. The sum of the discharge distribution through the bridge openings, presented later in this report, did not equal 100 percent for all scenarios simulated. Usually, +/- 3 percent error is considered acceptable for the type of model simulations performed for this report, and model results were within this range with the exception of Alternative 1, which was +/- 5 percent.

The software package Surface-Water Modeling System (SMS) (Brigham Young University, 1999) was used to construct the computational grid representing the flow system in this report. The grid was constructed using an automated grid generator in SMS, surveying data supplied by the AHTD and USGS, and a 10-m digital elevation model (DEM). SMS uses vertex triangulation methods in which vertices (nodes) are distributed through the model domain and then connected appropriately by a triangulation algorithm. Nodes were created using the 10-m DEM data. DEM data were generated from topographic maps having 5-ft contour intervals and were verified by surveying five cross sections in the White River flood plain using total station and GPS units. Surveying data verified the accuracy of DEM data and no adjustments to the DEM data were necessary (fig. 5). The finite-element grid used for modeling the existing and natural conditions for this report consisted of nearly 11,000 elements and almost 36,000 nodes; the grid for the proposed condition consisted of nearly 11,000 elements and almost 40,000 nodes.

Boundary Conditions

Boundary conditions are established around the perimeter of a finite-element grid and identified as either closed or open. Closed boundaries represent obstructions, such as shorelines, embankments, and levees, that do not allow flow to pass through. The locations of the closed boundaries representing the shorelines in this report were estimated using the ground elevations obtained from the DEM's. For the simulations in this report, all solid boundaries were set up for tangential slip condition, which forces all flow adjacent to the solid boundaries to flow parallel to the boundaries. Flows also can be allowed to pass over solid

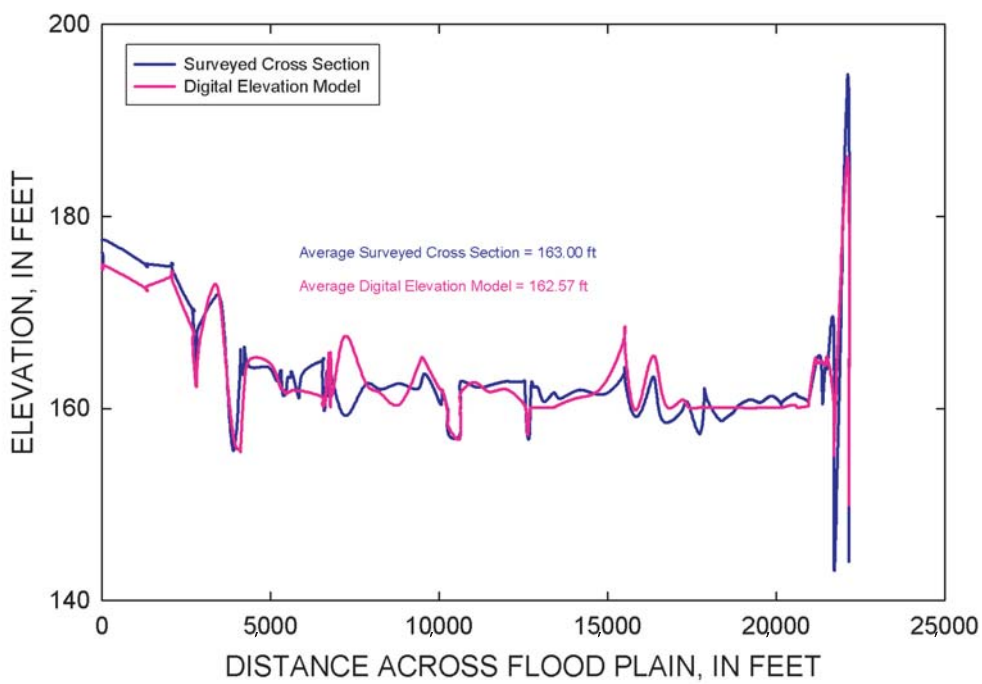

Figure 5. Verification of the 10-meter digital elevation model data with the most downstream surveyed cross section.

boundaries to simulate weir flows over embankments. However, because both the existing and proposed conditions have embankments that are higher than the 100-year floodflow, no weir flows were used for the simulations in this report.

Open boundaries represent boundaries that allow flow to enter or leave the finite-element grid. In this report, open boundaries are located at the upstream and downstream boundaries of the model area. The open boundary conditions at the upstream boundary are the discharges for the different flows being simulated. The open boundary conditions for the downstream boundary of the model area are water-surface elevations obtained from the gaging station at Aberdeen, Arkansas. The downstream boundary conditions from the gaging station are 168.5 and 173.2 ft for the 5- and 100-year flood, respectively.

Model Parameters

Several model parameters and options were considered and varied throughout the modeling process to ensure that the best simulation of floodflows was achieved. Manning's roughness coefficient and kinematic eddy viscosity were the two primary model parameters that were varied. Default values for all other modeling parameters were used for floodflow simulations. These parameters included the following: water density, air density, dimensionless turbulence coefficient, relaxation factor, depth tolerance, and coefficients used to compute the momentum correction coefficient. Additionally, a low-order numerical integration technique was performed for each simulation. Wind effects were ignored and a constant density was assumed (assumed that flow was well mixed vertically). Any unsteady effects of the floodflow were ignored. Some of the modeling options that were considered were (1) steady-state or time-dependent solution, (2) elements being "turned on" and "off" during a run or elements being left "on" (Froehlich, 1989), and (3) varying the number of iterations to be performed to reach a converged solution.

Model Calibration

Calibration is the process of adjusting model input parameters until a reasonable match is produced between simulated results and actual known data for the study area. Grid configuration, the selection of Manning's roughness coefficients, and the selection of kinematic eddy viscosities were based on engineering judgment and experience. Water-surface elevations were available for the 5- and 100-year floodflows at the USACE Aberdeen and Clarendon gaging stations by using the rating curves developed for the Clarendon and Aberdeen gages. Simulated water-surface elevations for each floodflow were calibrated to match the water-surface elevations at the Clarendon gaging station. Simulated water-surface elevations at the Clarendon gaging station from the calibrated model closely matched measured water-surface elevations (table 2). If default values for model parameters do not need to be adjusted to reach a solution comparable to the recorded data for the independent event, the model is commonly considered calibrated for a limited range of discharges. The model could not be validated because a separate recorded event was not available to simulate.

Table 2. Known and simulated water-surface elevation for the model calibration

[WSE, water-surface elevation above NGVD of 1929]

	Aberdeen assigned WSE (feet)	Clarendon known WSE (feet)	Clarendon simulated WSE (feet)
5-year floodflow	168.53	170.78	170.82
100-year floodflow	173.21	175.48	175.50

Sensitivity Analysis

Sensitivity analysis evaluates the response of the model to incremental changes in parameters. The evaluation provides information about the uncertainty in model results and the level of confidence in use of model results. Manning's roughness coefficients and base kinematic eddy viscosity (equations 4-19, Froehlich, 1989) were adjusted from the original values used in the calibrated model. Changes in Manning's roughness coefficients had substantial effects on the model results of the water-surface elevation across the flood plain (about 0.5 ft). Changes in base kinematic eddy viscosity also had substantial effects on the water-surface elevation across the flood plain. For each floodflow simulation, a beginning kinematic eddy viscosity of 250 ft^2/s was used. Once a convergence solution was reached for the targeted boundary conditions, the kinematic eddy viscosity was lowered in a series of steps by decreasing the kinematic eddy viscosity values by one-half. For kinematic eddy viscosities between 250 ft^2/s

and 40 ft^2/s, substantial changes in water-surface elevations (about 0.4 ft) occurred at the upstream boundaries. However, for kinematic eddy viscosities between 40 ft^2/s and 7 ft^2/s, changes in the water-surface elevations were less (less than 0.15 ft) at the upstream boundaries.

SIMULATION OF FLOODFLOWS

Floodflows for the 5- and 100-year floods were simulated for the existing, natural, and proposed conditions. The AHTD and USFWS have concerns about the backwater and velocity distributions caused by the proposed bridges during all flow conditions because the bridges are located in the National Wildlife Refuges.

For each of the four proposed alternatives, average upstream and downstream water-surface elevations as well as the water-surface elevation along the proposed U.S. Highway 79 alignment were estimated by taking the average of the water-surface elevations at a group of nodes on a line at the location of interest. Approach elevations were selected from a group of nodes on a line that stretched from the left bank to the right bank approximately 1 mi upstream from the simulated roadway alignment. Backwater then was estimated by subtracting the average water-surface elevations determined for the natural conditions from the average water-surface approach elevations determined for the existing and proposed conditions. Average bridge opening velocities were calculated by taking the average depth-averaged velocities at a group of nodes on a line that crossed the entire bridge opening from the left bridge abutment to the right bridge abutment.

5-Year Flood

Floodflows were simulated for the White River 5-year flood for the existing, natural, and proposed conditions. The estimated 5-year floodflow was 115,100 ft^3/s and has a 20 percent chance of being equaled or exceeded in any given year. During the 5-year flood, flow model simulations show that the floodwaters would breach the main channel of both the White River and Roc Roe Bayou and submerge the entire width of the flood plain in the study area. The average water depth computed for a series of nodes along a cross section at the upper model boundary was about 11 ft; the average water depth computed for a series of nodes along a cross section at the lower model boundary was about 10 ft. For the 5-year floodflow, the main channel of the White River ranges in depth from 25 to 60 ft, and the main channel of Roc Roe Bayou ranges in depth from 18 to 29 ft. Water-surface elevations for the 5-year flood event range from 171.9 ft above NGVD of 1929 at the upper model boundary to 168.5 ft above NGVD of 1929 at the lower model boundary.

Existing Conditions

The 5-year floodflow was simulated with the existing land use and roadway alignment in place. The simulation also included the Union Pacific Railroad embankment and bridge configuration that was in place prior to 1995, because the stage and discharge data used to calculate the flood frequency were collected prior to 1995. Simulation of the 5-year floodflow for the existing conditions indicates that about 57 percent (65,600 ft^3/s) of flow was conveyed by the White River bridge, about 26 percent (29,900 ft^3/s) by the First Old River bridge, and about 17 percent (19,600 ft^3/s) by the Roc Roe Bayou bridge. The maximum depth-averaged point velocities for the White River and First Old River bridges were 3.6 and 1.6 ft/s, respectively. Average water depths were 12 and 10 ft at the White River and First Old River bridges, respectively. The maximum depth-averaged point velocity predicted at the Roc Roe Bayou bridge was 3.3 ft/s with an average water depth of 8 ft. The average water-surface elevation at the upper model boundary was 171.9 ft, the average water-surface elevation along the U.S. Highway 79 roadway alignment was 171.5 ft, and the average water-surface elevation at lower model boundary was set at 168.5 ft (predetermined from a developed rating curve at the Aberdeen gaging station). Average water depths at the upper model boundary, U.S. Highway 79 roadway alignment, and the lower model boundary were 11 ft, 10 ft, and 10 ft, respectively. Simulated water-surface elevations for the 5-year floodflow for the existing conditions are shown on figure 6, the corresponding depth-averaged velocity contours are shown on figure 7, and the corresponding distribution of depth-averaged point velocity vectors near the existing U.S. Highway 79 roadway alignment is shown on figure 8.

Natural Conditions

Simulation of the 5-year floodflow for the natural conditions, that is, without U.S. Highway 79 or

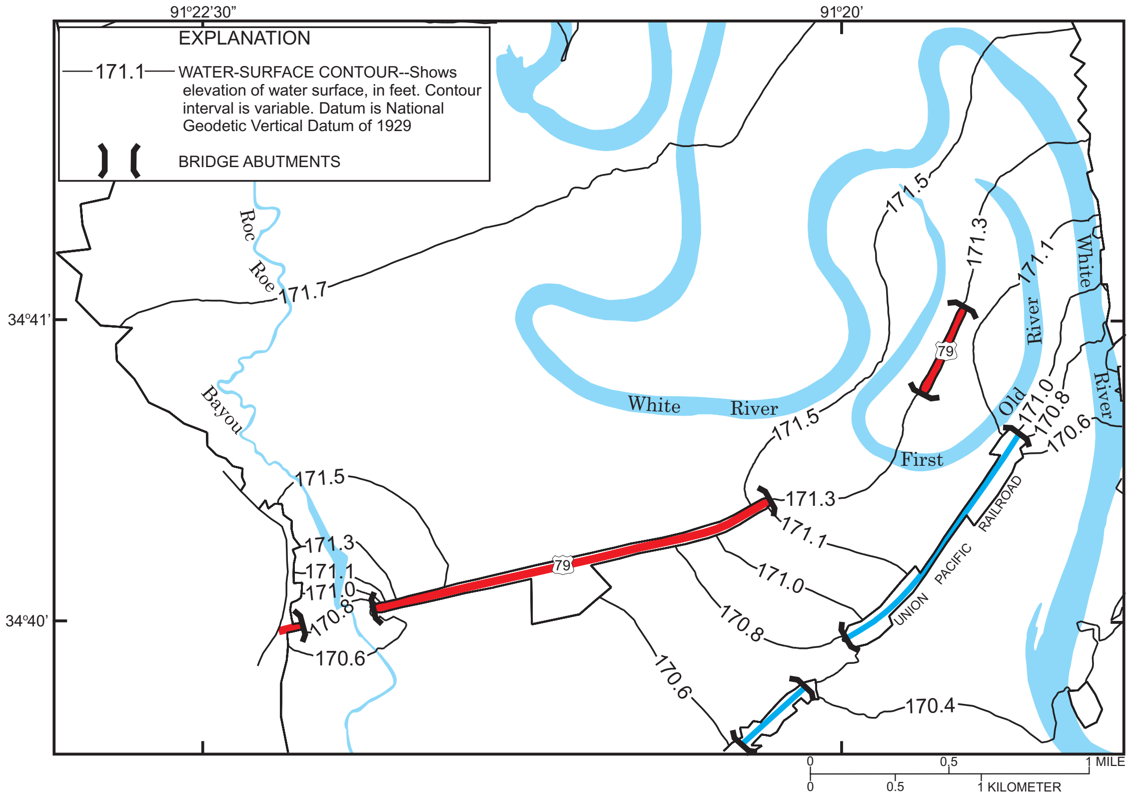

Figure 6. Simulated water-surface elevations for the 5-year floodflow through the existing U.S. Highway 79 roadway alignment.

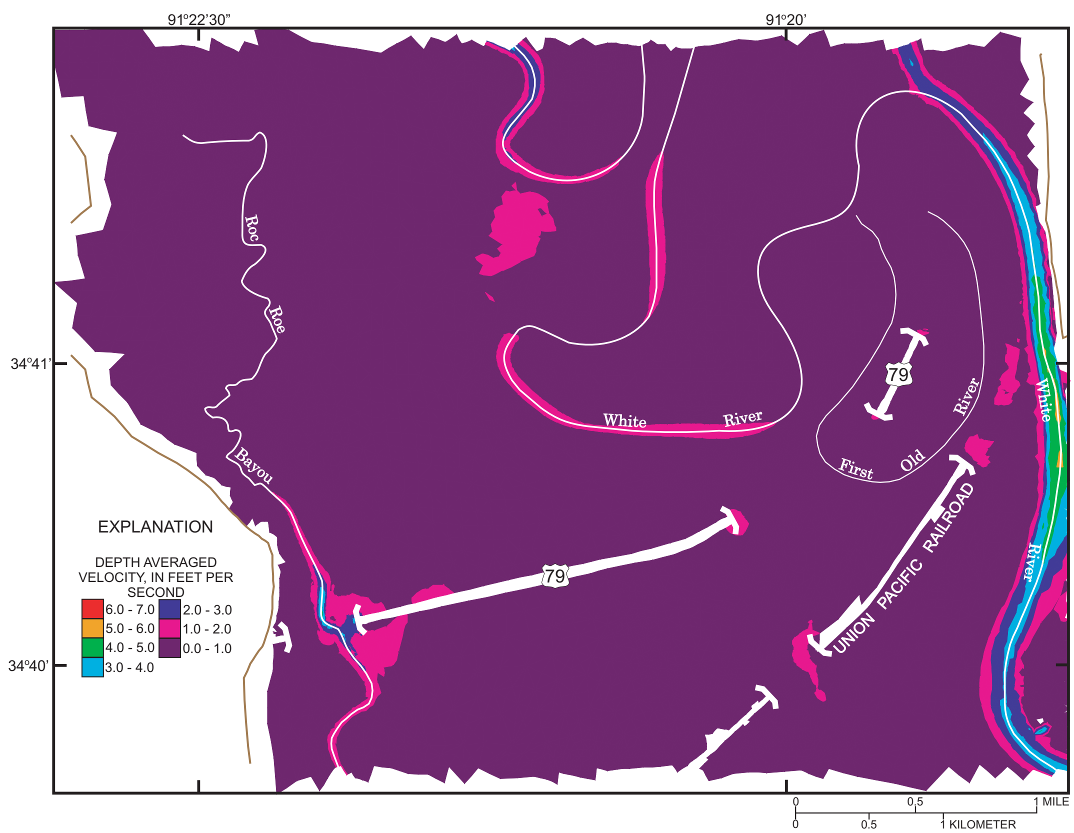

Figure 7. Depth-averaged velocity contours for the 5-year floodflow through the existing U.S. Highway 79 roadway alignment.

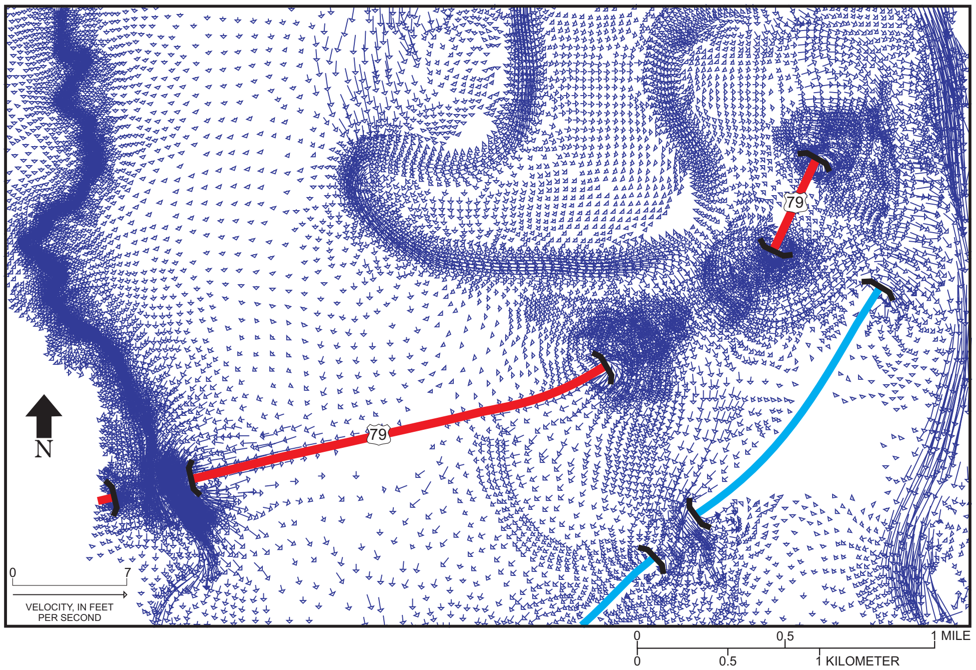

Figure 8. Distribution of depth-averaged point velocity vectors for the 5-year floodflow through the existing U.S. Highway 79 roadway alignment.

Union Pacific Railroad bridges and embankments, indicates maximum depth-averaged point velocities for an area near the location of the existing White River, First Old River and Roc Roe Bayou bridges were 2.9, 0.7, and 1.2 ft/s, respectively. Average water depths near the location of the existing bridge openings were 11, 9, and 7 ft for the White River, First Old River, and Roc Roe Bayou bridges, respectively. The average water-surface elevation at the upper model boundary was 171.4 ft; the average water-surface elevation near the location of the existing U.S. Highway 79 roadway alignment was 170.9 ft; the average water-surface elevation at the lower model boundary was set at 168.5 ft (predetermined from a developed rating curve at the Aberdeen gaging station). Average water depths at the upper model boundary, near the location of the existing U.S. Highway 79 roadway alignment, and at the lower model boundary were 10, 8, and 10 ft, respectively. The simulated water-surface elevations for the 5-year floodflow for natural conditions are shown on figure 9, the corresponding depth-averaged velocity contours are shown on figure 10, and the corresponding distribution of depth-averaged point velocity vectors near the location of the existing roadway bridges is shown on figure 11.

Proposed Conditions—Alternative 1

Simulation of the 5-year floodflow for the proposed Alternative 1 U.S. Highway 79 roadway alignment indicates that about 78 percent (89,900 ft^3/s) of the flow was conveyed by the proposed White River bridge, about 6 percent (7,400 ft^3/s) by the proposed 1,400-ft relief bridge, and about 13 percent (14,600 ft^3/s) by the proposed Roc Roe Bayou bridge (table 3). Although average velocities for Alternative 1 through each bridge opening were very similar to velocities through the bridge openings for existing conditions, the maximum point velocities through the White River bridge opening increase moderately compared to existing conditions (table 3). Water-surface elevations range from 171.0 ft to 171.4 ft through the bridge openings (fig. 12), and the maximum depth averaged point velocities occur around the bridge abutments for each opening (figs. 13-14, table 3).

The average backwater caused by the simulated proposed Alternative 1 U.S. Highway 79 bridges was

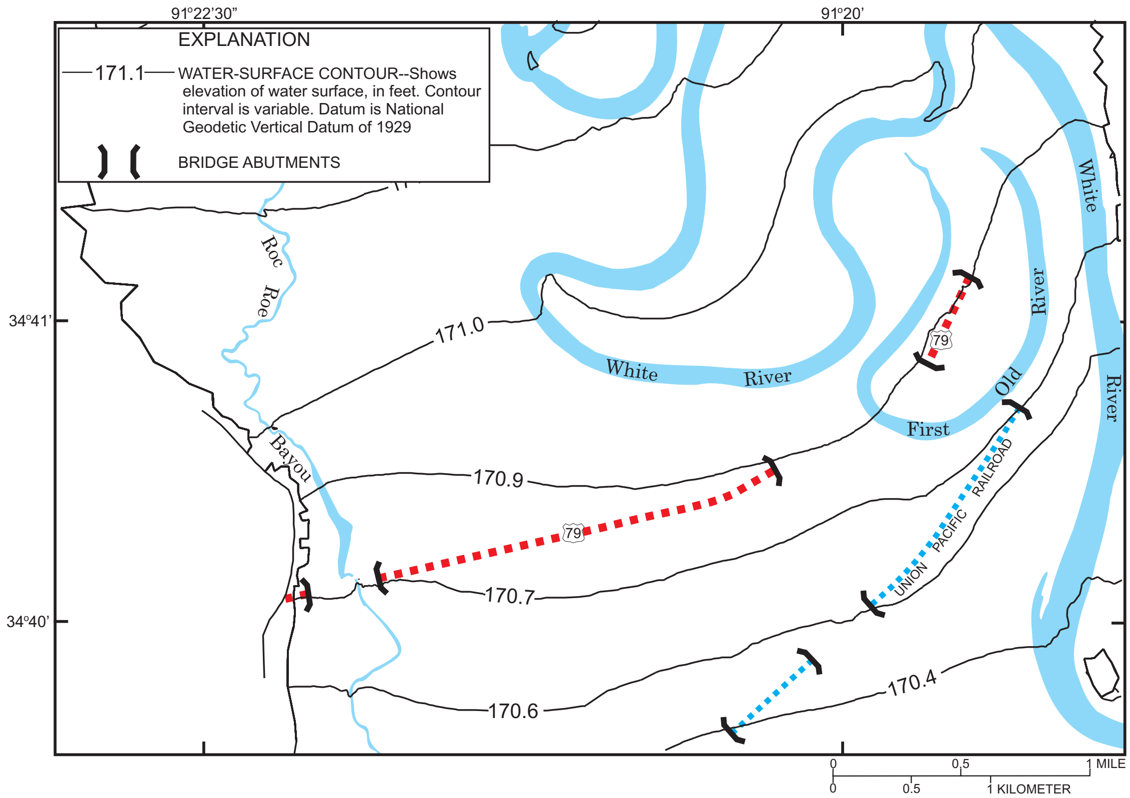

Figure 9. Simulated water-surface elevations for the 5-year floodflow for natural conditions through the White River flood plain at the U.S. Highway 79 crossing (embankments are transparent as to illustrate flow through roadway for natural conditions).

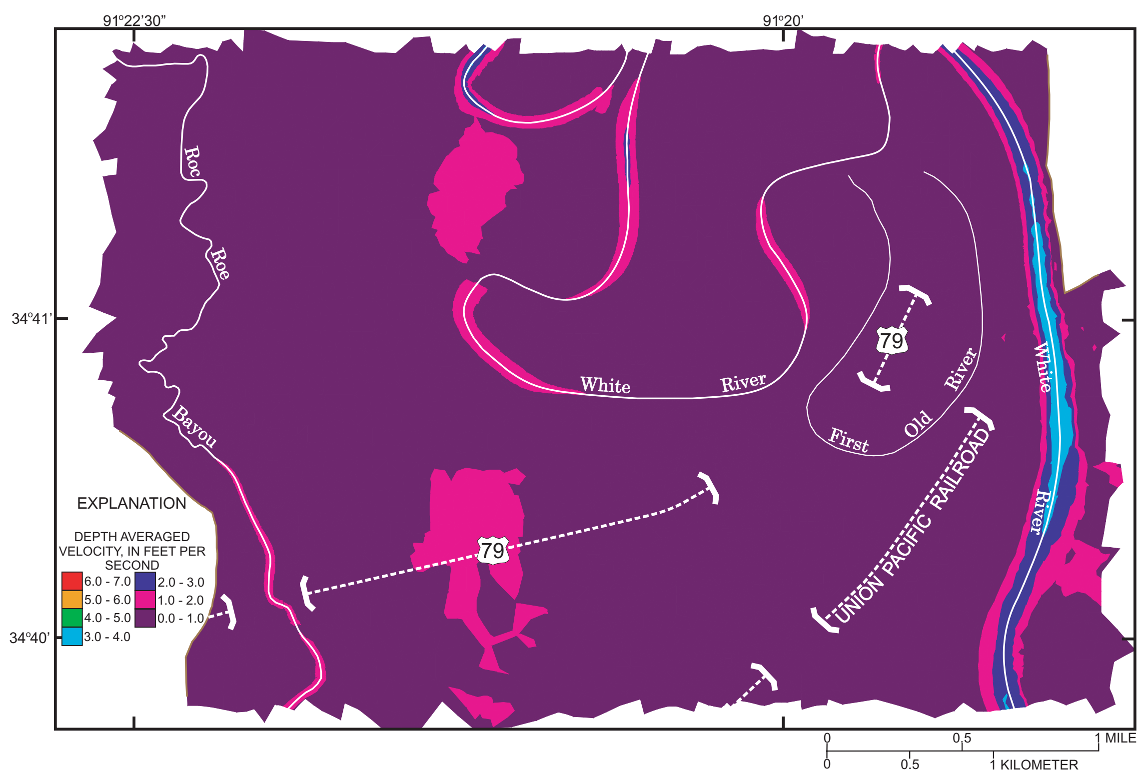

Figure 10. Depth-averaged velocity contours for the 5-year floodflow for natural conditions through the White River flood plain at the U.S. Highway 79 crossing (embankments are transparent as to illustrate flow through roadway for natural conditions).

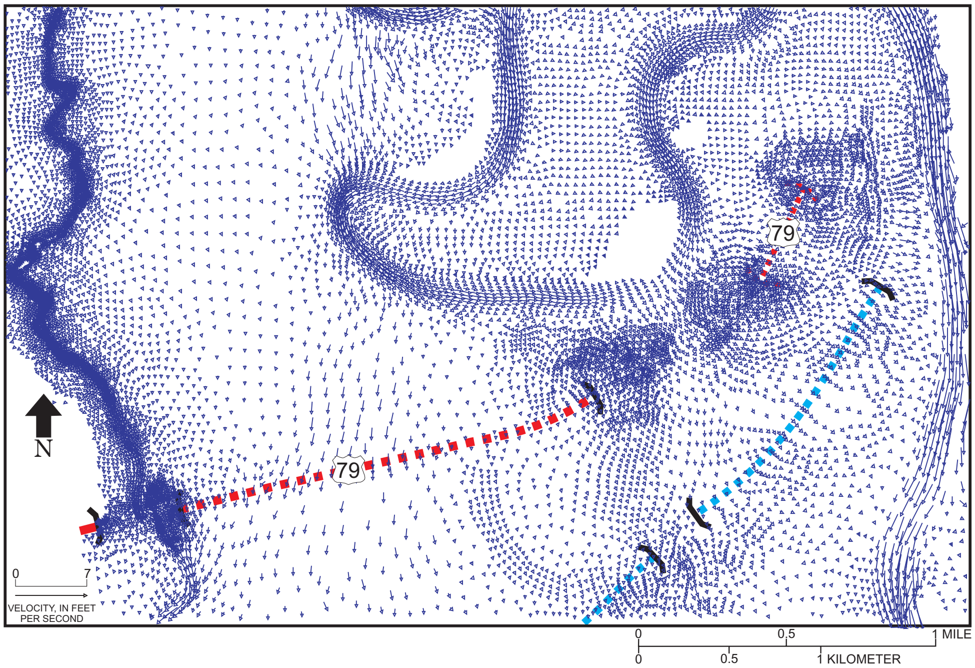

Figure 11. Distribution of depth-averaged point velocity vectors for the 5-year floodflow for natural conditions through the White River flood plain at the U.S. Highway 79 crossing (embankments are transparent as to illustrate flow through roadway for natural conditions).

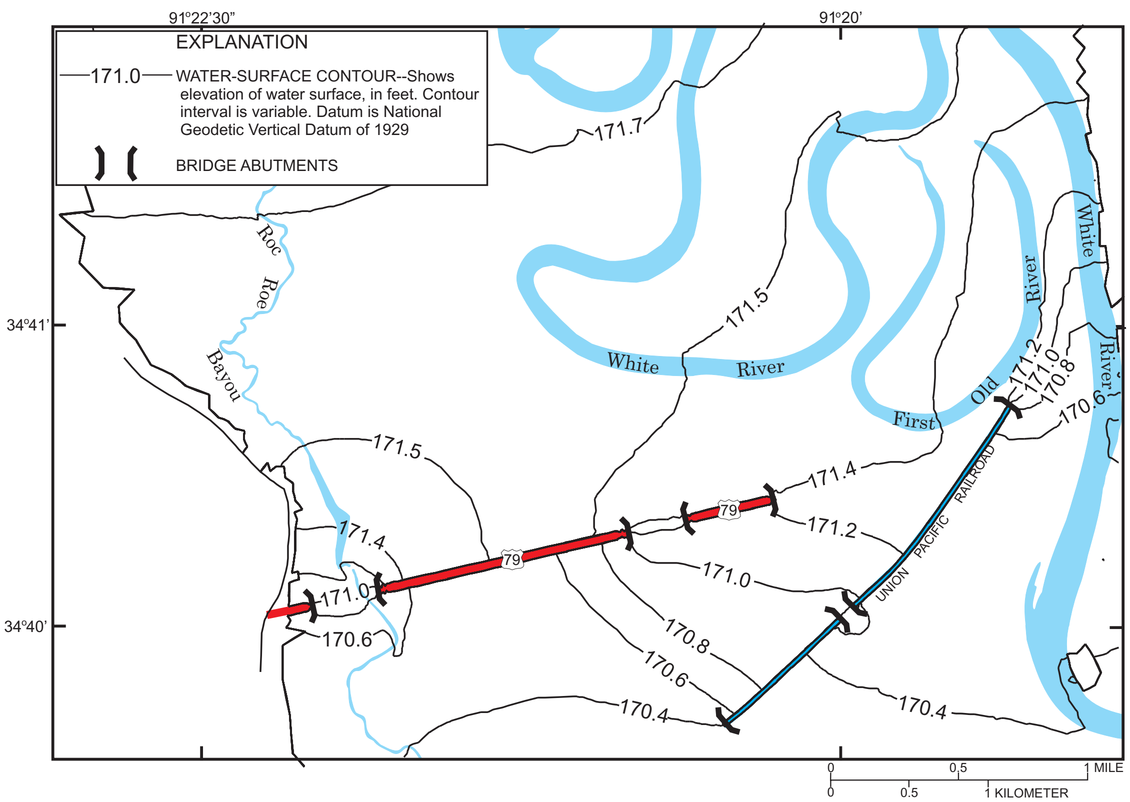

Figure 12. Simulated water-surface elevations for the 5-year floodflow through the proposed Alternative 1 U.S. Highway 79 roadway alignment.

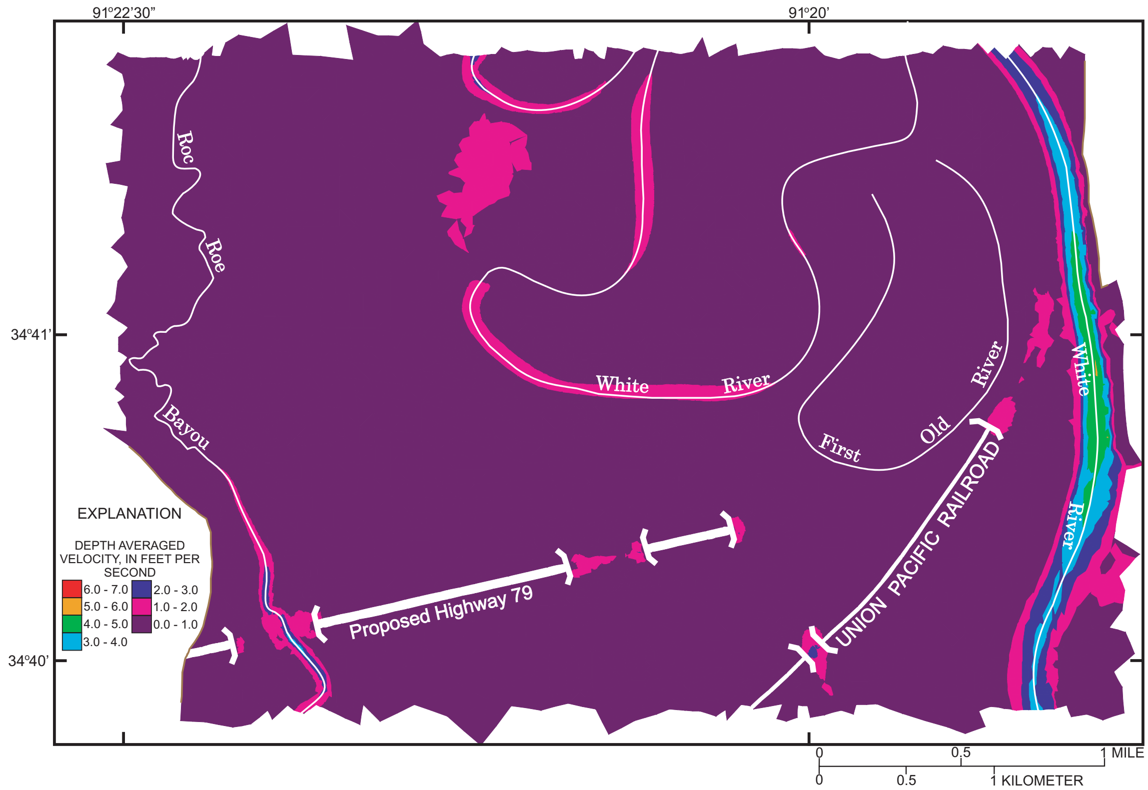

Figure 13. Depth-averaged velocity contours for the 5-year floodflow through the proposed Alternative 1 U.S. Highway 79 roadway alignment.

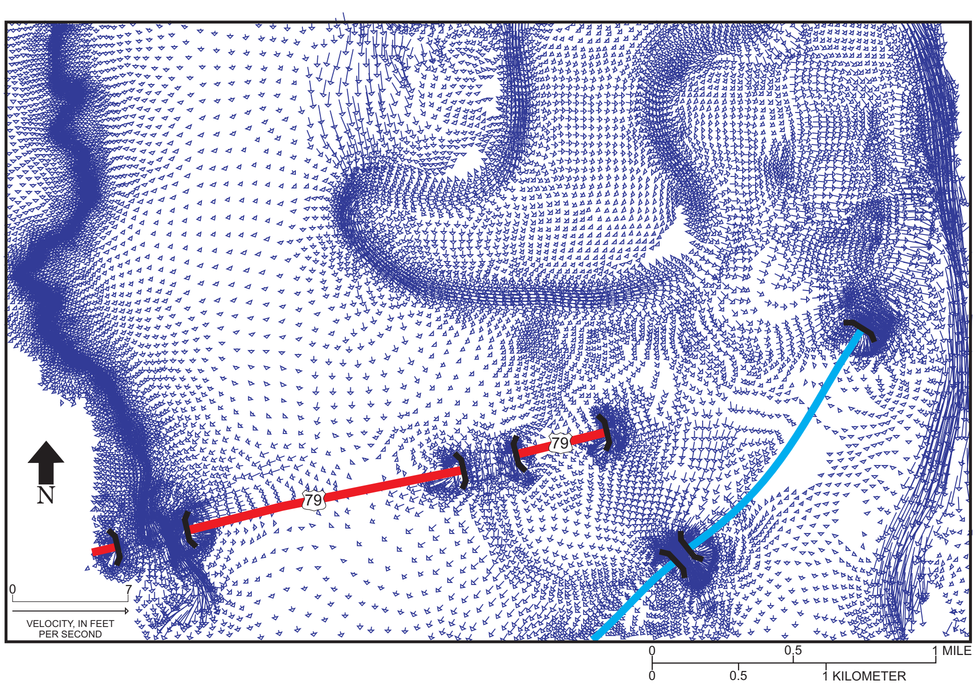

Figure 14. Distribution of depth-averaged point velocity vectors for the 5-year floodflow through the proposed Alternative 1 U.S. Highway 79 roadway alignment.

Table 3. Hydraulic data for the White River flood plain U.S. Highway 79 roadway alignment for simulated floodflows having a 5-year recurrence interval

WHITE RIVER FLOOD PLAIN CROSSING 5-YEAR FLOOD EVENT							
Simulated conditions and U.S. Highway 79 bridge opening	**Discharge distribution (cubic feet per second)**	**Discharge distribution (percent)**	**Backwater at approach section (feet)**	**Average velocity through bridge openings (feet per second)**	**Maximum velocity through bridge openings (feet per second)**	**Location of maximum velocity (feet per second)**	**Average depth of water through bridge opening (feet)**
Existing							
White River Bridge	65,600	57		1.0	3.6	Main channel	12
First Old River Bridge	29,900	26	0.4	0.8	1.6	Right bridge abutment	10
Roc Roe Bayou Bridge	19,600	17		1.6	3.3	Main channel	8
Natural							
White River Bridge area[1]				0.6	2.9	Main channel	11
First Old River Bridge area[1]		not applicable	not applicable	0.5	0.7	Main channel	9
Roc Roe Bayou Bridge area[1]				0.6	1.2	Main channel	7
Proposed Alternative 1							
White River Bridge	89,900	78		0.9	4.6	Main channel	10
1,400-Foot Relief Bridge	7,400	6	0.5	0.8	1.7	Right bridge abutment	5
Roc Roe Bayou Bridge (1,540 Foot Bridge)	14,600	13		1.0	2.9	Main channel	6
Proposed Alternative 2							
White River Bridge	89,900	78		0.8	4.5	Main channel	12
1,545-Foot Relief Bridge	7,500	7	0.2	1.1	2.0	Right bridge abutment	5
Roc Roe Bayou Bridge (2,475 Foot Bridge)	16,200	14		1.2	2.3	Main channel	7
Proposed Alternative 3							
White River Bridge	89,900	78		0.8	4.4	Main channel	12
1,545-Foot Relief Bridge	7,500	7	0.2	1.1	2.0	Right bridge abutment	5
Roc Roe Bayou Bridge (3,475 Foot Bridge)	16,600	14		0.9	2.2	Main channel	6
Proposed Alternative 4							
White River Bridge	87,100	76		0.8	4.3	Main channel	12
1,545-Foot Relief Bridge	7,000	6	0.2	1.0	1.9	Right bridge abutment	5
Roc Roe Bayou Bridge (3,475 Foot Bridge)	18,600	16		1.0	2.0	Main channel	7

[1]Locations near existing openings. Bridges and embankments removed for the hypothetical natural conditions.

0.5 ft for the 5-year floodflow. A complete tabulation of the hydraulic data for the 5-year floodflow for the bridges for proposed Alternative 1 is in table 3.

Proposed Conditions—Alternative 2

Simulation of the 5-year floodflow for the proposed Alternative 2 U.S. Highway 79 roadway alignment indicates that about 78 percent (89,900 ft^3/s) of the flow was conveyed by the proposed White River bridge, about 7 percent (7,500 ft^3/s) by the proposed 1,545-ft relief bridge, and about 14 percent (16,200 ft^3/s) by the proposed Roc Roe Bayou bridge (table 3). Although average velocities for Alternative 2 through each bridge opening were very similar to velocities through the bridge openings for existing conditions, the maximum point velocities through the White River bridge opening increase moderately compared to existing conditions (table 3). Water-surface elevations range from 171.0 ft to 171.4 ft through the bridge openings (fig. 15), and the maximum depth averaged point velocities occur around the bridge abutments for each opening (figs. 16-17, table 3).

The average backwater caused by the proposed Alternative 2 U.S. Highway 79 bridges was 0.2 ft for the 5-year floodflow. A complete tabulation of the hydraulic data for the 5-year floodflow for the bridges for proposed Alternative 2 is listed in table 3.

Proposed Conditions—Alternative 3

Simulation of the 5-year floodflow for the proposed Alternative 3 U.S. Highway 79 roadway alignment indicates that about 78 percent (89,900 ft^3/s) of the flow was conveyed by the proposed White River bridge, about 7 percent (7,500 ft^3/s) by the proposed 1,545-ft relief bridge, and about 14 percent (16,600 ft^3/s) by the proposed Roc Roe Bayou bridge (table 3). Although average velocities for Alternative 3 through each bridge opening were very similar to velocities through the bridge openings for existing conditions, the maximum point velocities through the White River bridge opening increase moderately compared to existing conditions (table 3). Water-surface elevations range from 171.0 ft to 171.4 ft through the bridge openings (fig. 18), and the maximum depth averaged point velocities occur around the bridge abutments for each opening (figs. 19-20, table 3).

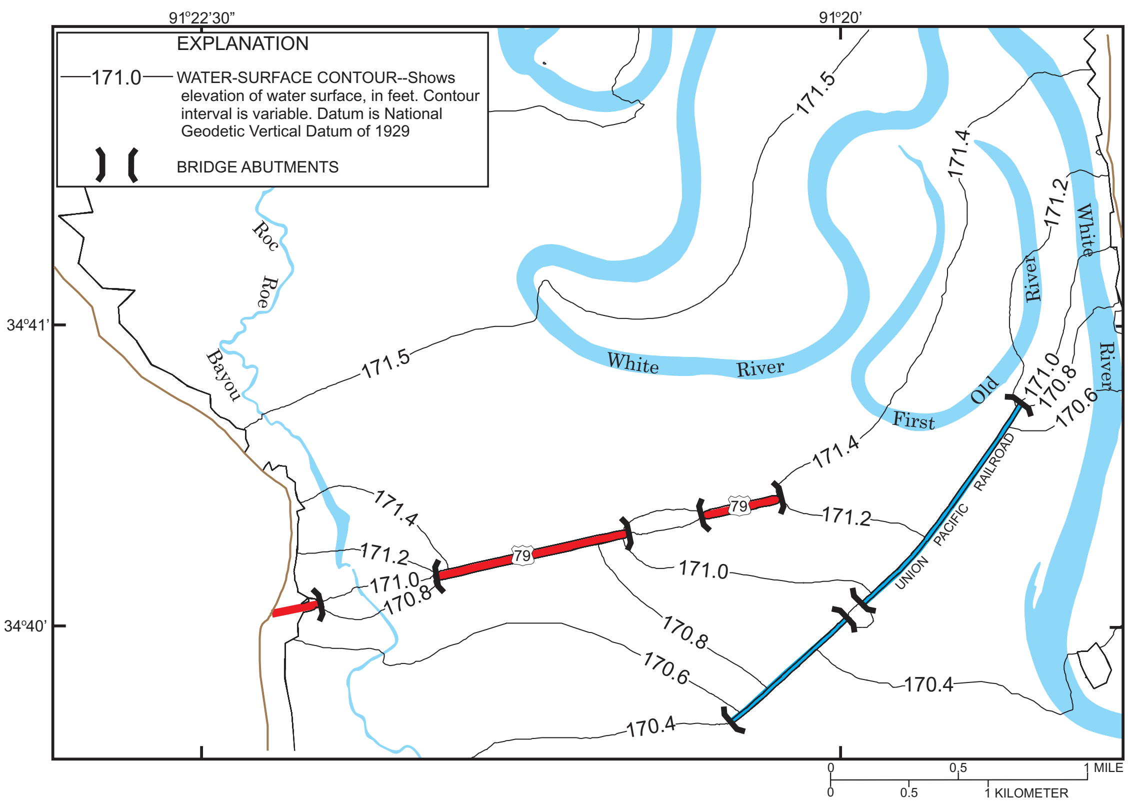

Figure 15. Simulated water-surface elevations for the 5-year floodflow through the proposed Alternative 2 U.S. Highway 79 roadway alignment.

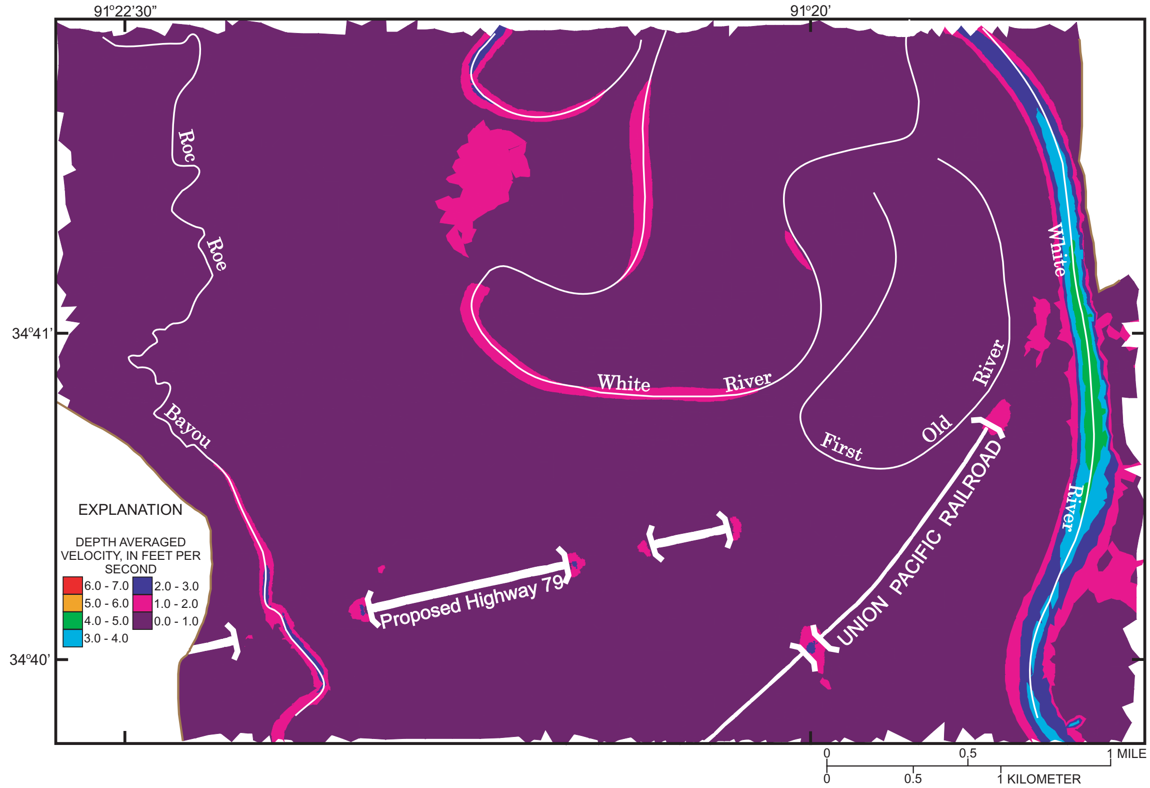

Figure 16. Depth-averaged velocity contours for the 5-year floodflow through the proposed Alternative 2 U.S. Highway 79 roadway alignment.

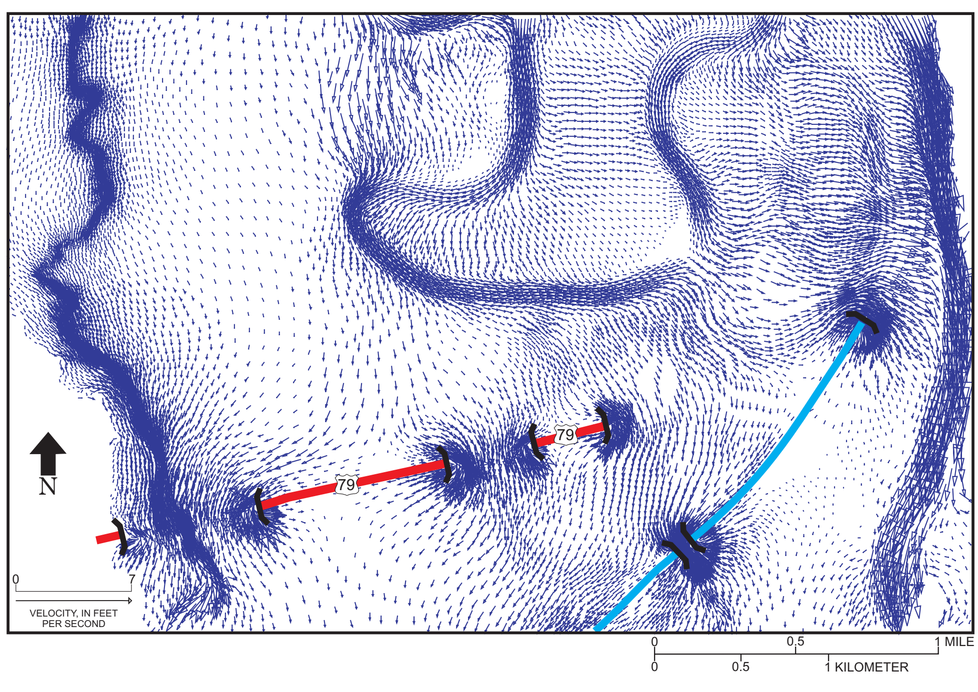

Figure 17. Distribution of depth-averaged point velocity vectors for the 5-year floodflow through the proposed Alternative 2 U.S. Highway 79 roadway alignment.

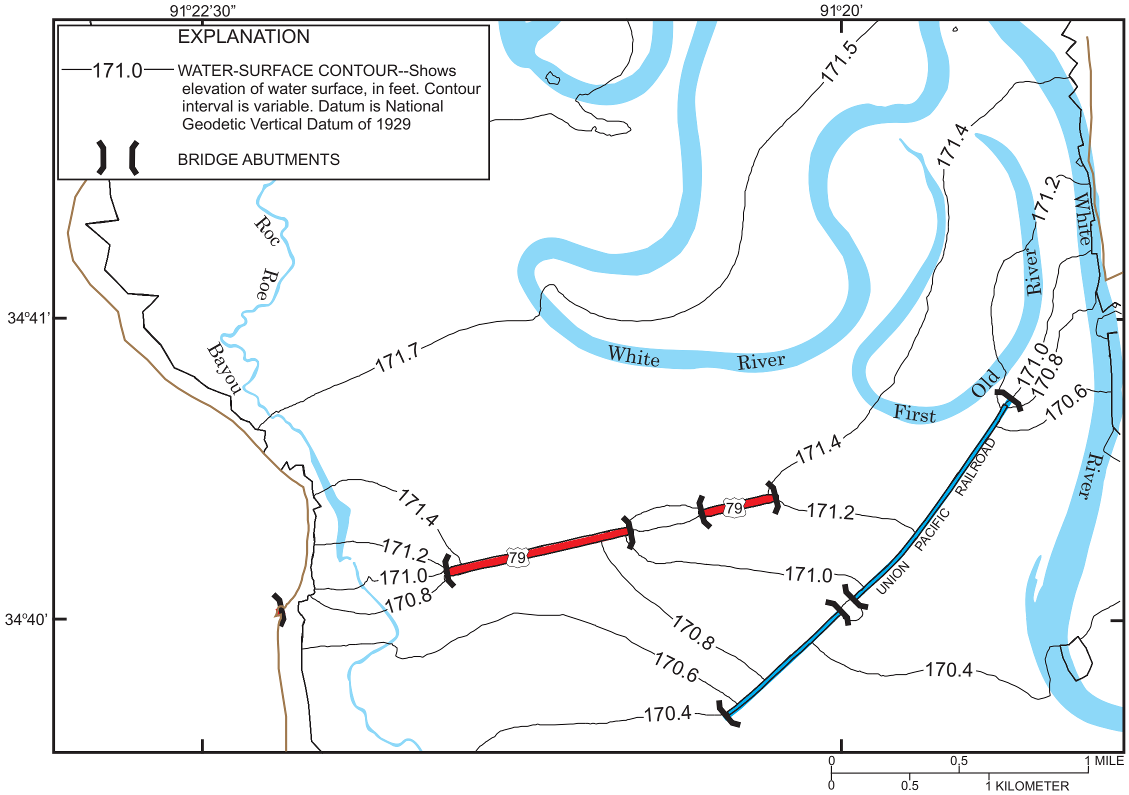

Figure 18. Simulated water-surface elevations for the 5-year floodflow through the proposed Alternative 3 U.S. Highway 79 roadway alignment.

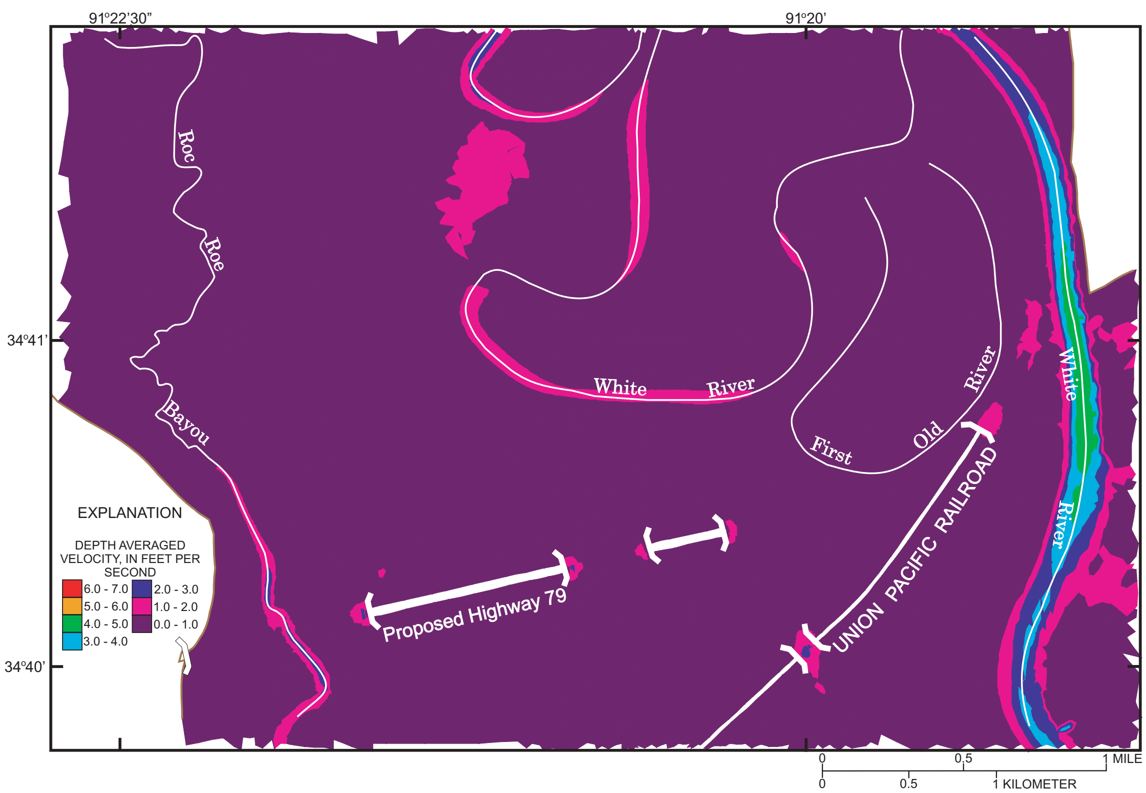

Figure 19. Depth-averaged velocity contours for the 5-year floodflow through the proposed Alternative 3 U.S. Highway 79 roadway alignment.

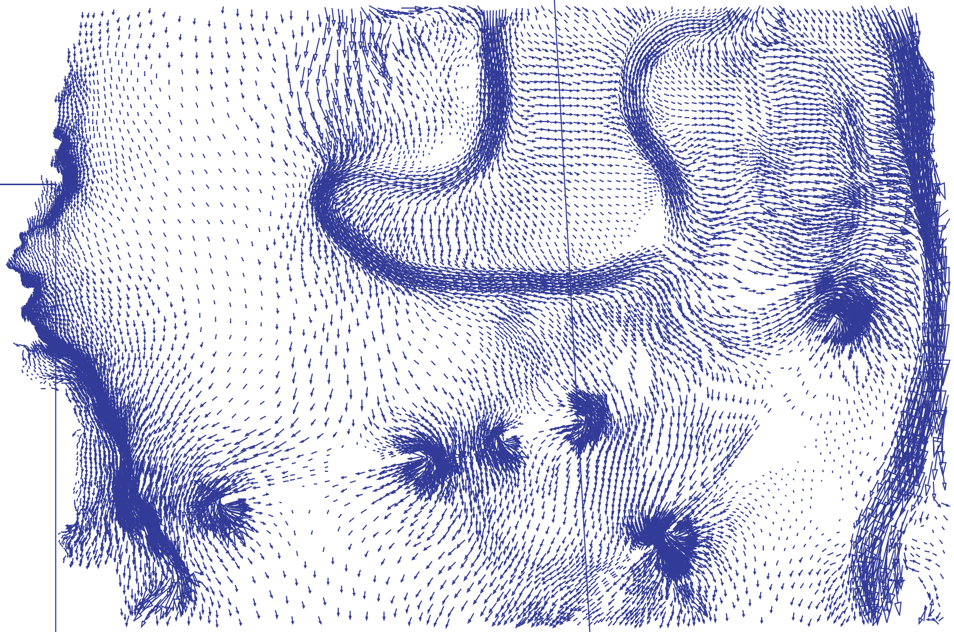

Figure 20. Distribution of depth-averaged point velocity vectors for the 5-year floodflow through the proposed Alternative 3 U.S. Highway 79 roadway alignment.

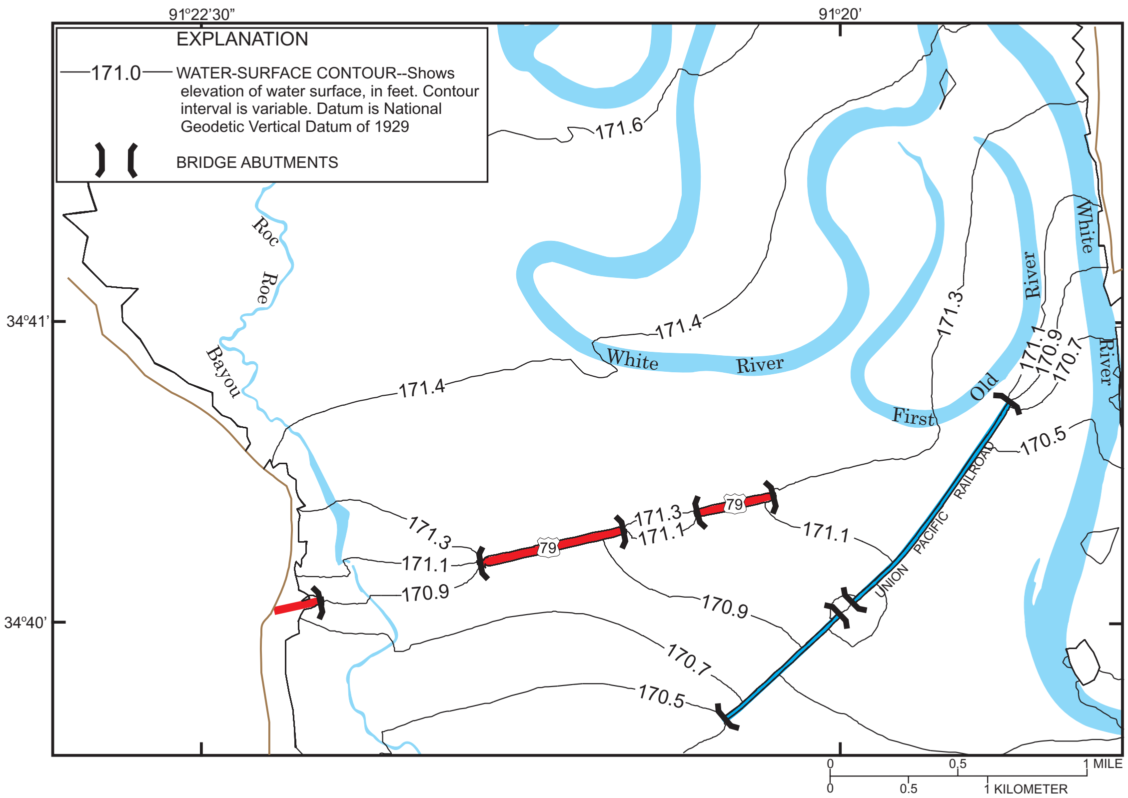

Figure 21. Simulated water-surface elevations for the 5-year floodflow through the proposed Alternative 4 U.S. Highway 79 roadway alignment.

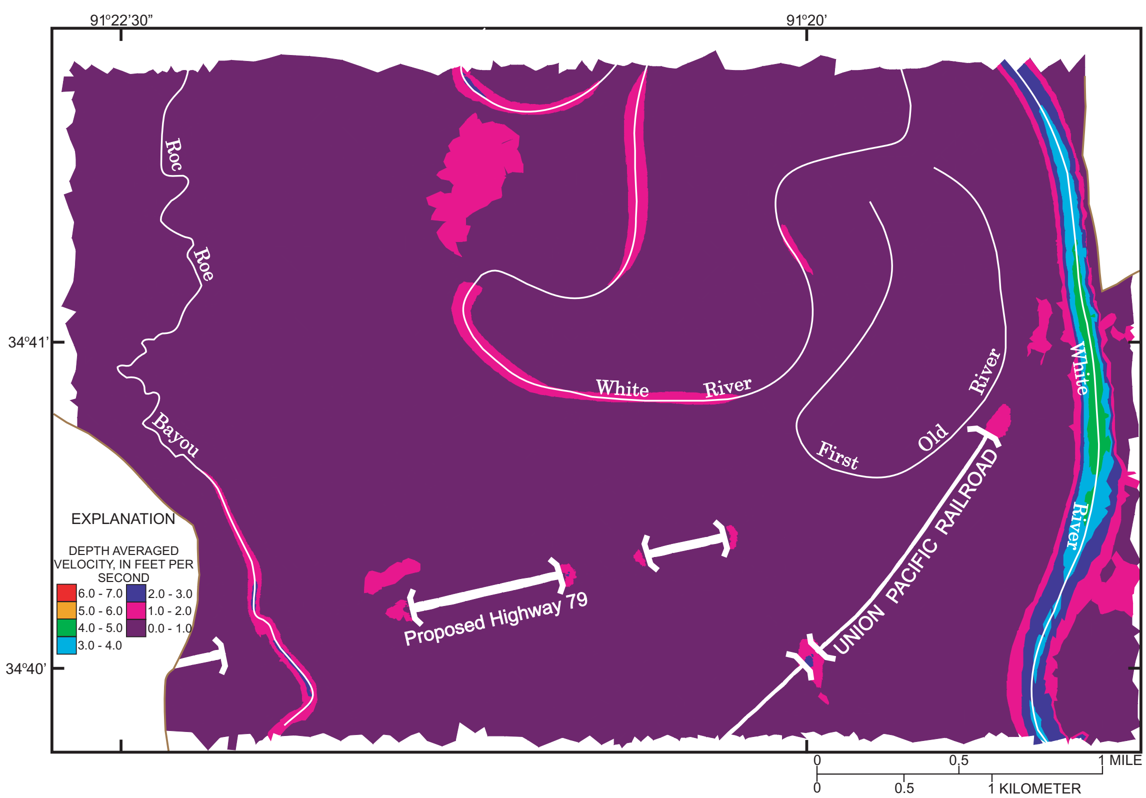

Figure 22. Depth-averaged velocity contours for the 5-year floodflow through the proposed Alternative 4 U.S. Highway 79 roadway alignment.

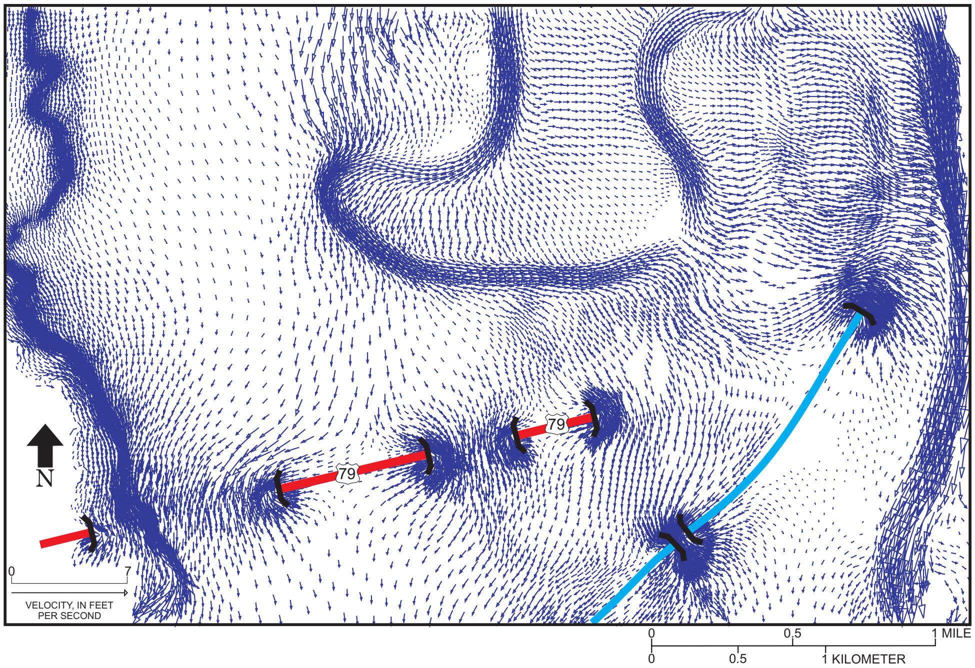

Figure 23. Distribution of depth-averaged point velocity vectors for the 5-year floodflow through the proposed Alternative 4 U.S. Highway 79 roadway alignment.

second) across the Roc Roe Bayou bridge opening than for existing conditions. However, as table 3 illustrates, these differences are relatively small and the locations of the maximum depth averaged point velocity does not change between each alternative and existing bridge openings. A comparison of backwater and velocity for each alternative to existing conditions is shown in table 4.

100-Year Flood

The estimated 100-year floodflow is 216,000 ft^3/s and has a 1 percent chance of being equaled or exceeded in any given year. Model simulations show that the entire White River flood plain in the study area becomes submerged during the 100-year floodflow. Average depths computed for a series of nodes along a cross section at the upper model boundary was about 15 ft; the average water depth computed for a series of nodes along a cross section at the lower model boundary was about 14 ft. For the 100-year floodflow, the main channel of the White River ranges in depth from 32 to 65 ft, and the main channel of Roc Roe Bayou ranges in depth from 20 to 33 ft. Water-surface elevations for the 100-year floodflow range from 176.9 ft above NGVD of 1929 at the upper model boundary to 173.2 ft above NGVD of 1929 at the lower model boundary.

Existing Conditions

The 100-year floodflow was simulated with the existing land use and roadway alignment in place. The simulation also included the Union Pacific Railroad embankment and bridge configuration that was in place prior to 1995, because stage and discharge data used to calculate the flood frequency were collected prior to 1995. Simulation of the 100-year floodflow indicates that about 56 percent (123,100 ft^3/s) of flow was conveyed by the White River bridge, about 26 percent (56,200 ft^3/s) by the First Old River bridge, and about 19 percent (41,000 ft^3/s) by the Roc Roe Bayou bridge (table 5). The maximum depth-averaged point velocities for the White River and First Old River bridges were 4.2 and 2.2 ft/s, respectively. Average water depths were 16 and 15 ft at the White River and First Old River bridges, respectively. The maximum depth-averaged point velocity at the Roc Roe Bayou bridge was 4.1 ft/s with an average water depth of 13 ft

Table 4. Comparison of backwater and velocity data for each alternative to existing conditions for simulated floodflows having a 5-year recurrence interval

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Change in backwater elevation (in feet)	+0.1	-0.2	-0.2	-0.2
Change in average velocity across White river bridge (in feet per second)	-0.1	-0.2	-0.2	-0.2
Change in average velocity across Roc Roe Bayou bridge (in feet per second)	-0.6	-0.4	-0.7	-0.6
Change in maximum velocity across White River bridge (in feet per second)	+1.0	+0.9	+0.8	+0.8
Change in maximum velocity across Roc Roe Bayou bridge (in feet per second)	-0.4	-1.0	-1.1	-1.3

(table 5). The average water-surface elevation at the upper model boundary was 176.9 ft; the average water-surface elevation along the U.S. Highway 79 roadway alignment was 176.3 ft; and the average water-surface elevation at the lower model boundary was set at 173.2 ft (predetermined from a developed rating curve at the Aberdeen gaging station). Average depths at the upper model boundary, the U.S. Highway 79 roadway alignment, and the lower model boundary were 15, 14, and 14 ft, respectively. The simulated water-surface elevations for the 100-year floodflow for existing conditions are shown on figure 24, the corresponding depth-averaged velocity contours are shown on figure 25, and the corresponding distribution of depth-averaged velocity vectors near the existing U.S. Highway 79 bridges is shown on figure 26.

Natural Conditions

Simulation of the 100-year floodflow for the natural conditions, that is, without U.S. Highway 79 or Union Pacific Railroad bridges and embankments, indicates maximum depth-averaged point velocities for an area near the location of the existing White River, First Old River, and Roc Roe Bayou bridges were 3.3, 0.9, and 1.3 ft/s, respectively (table 5). Average water depths near the location of the existing bridge openings were 15, 16, and 11 ft for the White River, the First Old River, and Roc Roe Bayou bridges, respectively (table 5). The average water-surface elevation at the upper model boundary was 176.2 ft, the average water-surface elevation near the location of the existing U.S. Highway 79 roadway alignment was 175.4 ft, and the average water-surface elevation at the lower model boundary was set at 173.2 ft (predetermined from a developed rating curve at the Aberdeen gaging station). Average water depths at the upper model boundary, near the location of the existing U.S. Highway 79 roadway alignment, and the lower model boundary were 15, 14, and 14 ft, respectively. The simulated water-surface elevations for the 100-year flood for the natural conditions are shown on figure 27, the corresponding depth-averaged velocity contours are shown on figure 28, and the corresponding distribution of depth-averaged point velocity vectors near the location of the existing roadway bridges is shown on figure 29.

Proposed Conditions—Alternative 1

Simulation of the 100-year floodflow for the proposed Alternative 1 U.S. Highway 79 roadway alignment indicates that about 72 percent (155,500 ft^3/s) of the flow was conveyed by the proposed White River bridge, about 9 percent (19,900 ft^3/s) by the proposed 1,400-ft relief bridge, and about 14 percent (30,700 ft^3/s) by the proposed Roc Roe Bayou bridge (table 5). Although average velocities for Alternative 1 through each bridge opening were very similar to velocities through the bridge openings for existing conditions, the maximum point velocities through the White River

Table 5. Hydraulic data for the White River flood plain U.S. Highway 79 roadway alignment for simulated floodflows having a 100-year recurrence interval

WHITE RIVER FLOOD PLAIN CROSSING
100-YEAR FLOOD EVENT

Simulated conditions and U.S. Highway 79 bridge opening	Discharge distribution (cubic feet per second)	Discharge distribution (percent)	Backwater at approach section (feet)	Average velocity through bridge openings (feet per second)	Maximum velocity through bridge openings (feet per second)	Location of maximum velocity (feet per second)	Average depth of water through bridge opening (feet)
Existing							
White River Bridge	123,100	56		1.4	4.2	Main channel	16
First Old River Bridge	56,200	26	0.8	1.2	2.2	Right bridge abutment	15
Roc Roe Bayou Bridge	41,000	19		2.3	4.1	Left bridge abutment	13
Natural							
White River Bridge area[1]				0.8	3.3	Main channel	15
First Old River Bridge area[1]		not applicable	not applicable	0.7	0.9	Main channel	16
Roc Roe Bayou Bridge area[1]				0.6	1.3	Main channel	11
Proposed Alternative 1							
White River Bridge	155,500	72		1.2	5.4	Main channel	17
1,400 Foot Relief Bridge	19,900	9	0.6	1.5	2.4	Right bridge abutment	10
Roc Roe Bayou Bridge (1,540 Foot Bridge)	30,700	14		1.9	2.9	Left bridge abutment	12
Proposed Alternative 2							
White River Bridge	155,600	72		1.1	5.4	Main channel	17
1,545 Foot Relief Bridge	20,700	10	0.4	1.5	2.5	Right bridge abutment	10
Roc Roe Bayou Bridge (2,475 Foot Bridge)	36,500	17		1.6	2.4	Left bridge abutment	11
Proposed Alternative 3							
White River Bridge	155,100	72		1.1	5.3	Main channel	16
1,545 Foot Relief Bridge	20,600	10	0.3	1.5	2.4	Right bridge abutment	10
Roc Roe Bayou Bridge (3,475 Foot Bridge)	37,300	17		1.2	2.4	Left bridge abutment	10
Proposed Alternative 4							
White River Bridge	151,200	70		1.1	5.1	Main channel	17
1,545 Foot Relief Bridge	19,800	9	0.3	1.4	2.2	Right bridge abutment	10
Roc Roe Bayou Bridge (3,475 Foot Bridge)	43,000	20		1.3	2.1	Left bridge abutment	11

[1]Locations near existing bridge openings. Bridges and embankments removed for the hypothetical natural conditions.

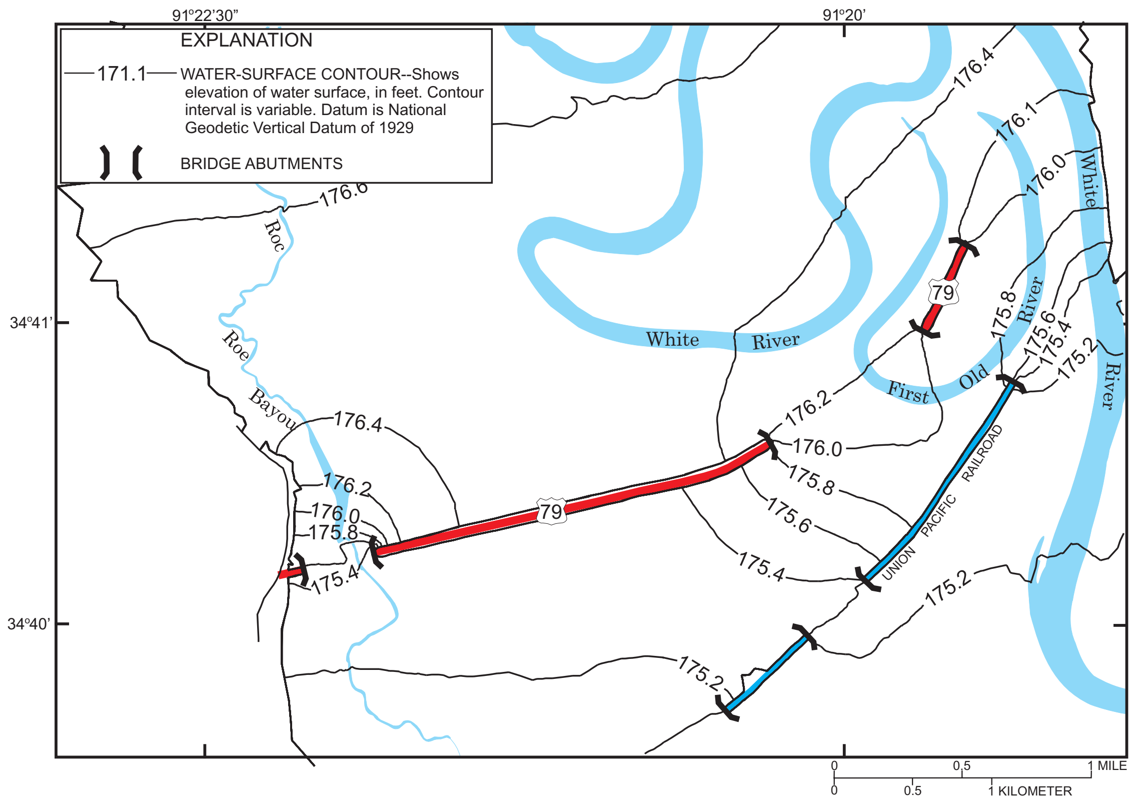

Figure 24. Simulated water-surface elevations for the 100-year floodflow through the existing U.S. Highway 79 roadway alignment.

Figure 25. Depth-averaged velocity contours for the 100-year floodflow through the existing U.S. Highway 79 roadway alignment.

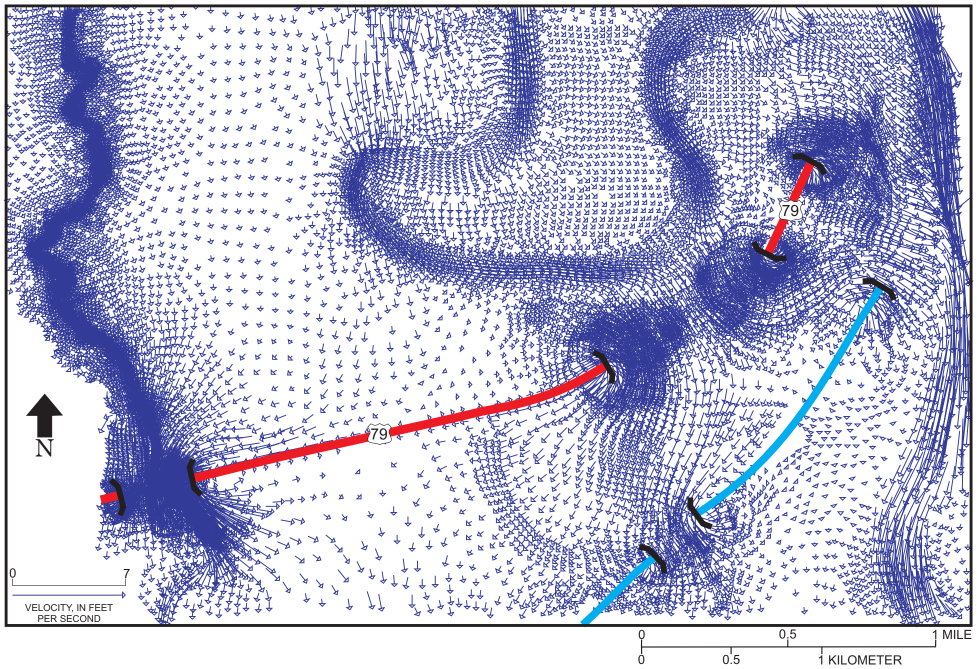

Figure 26. Distribution of depth-averaged point velocity vectors for the 100-year floodflow for natural conditions through the existing U.S. Highway 79 openings.

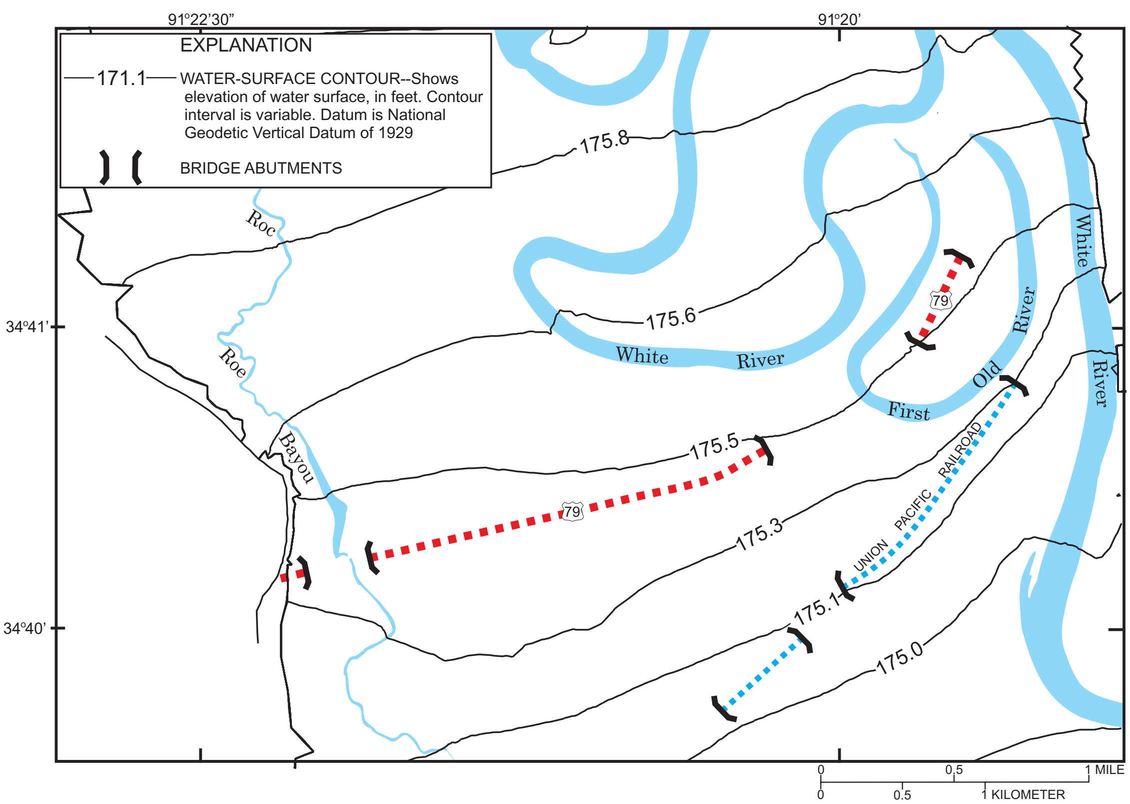

Figure 27. Simulated water-surface elevations for the 100-year floodflow for natural conditions through the White River flood plain at the U.S. Highway 79 crossing (embankments are transparent as to illustrate flow through roadway for natural conditions).

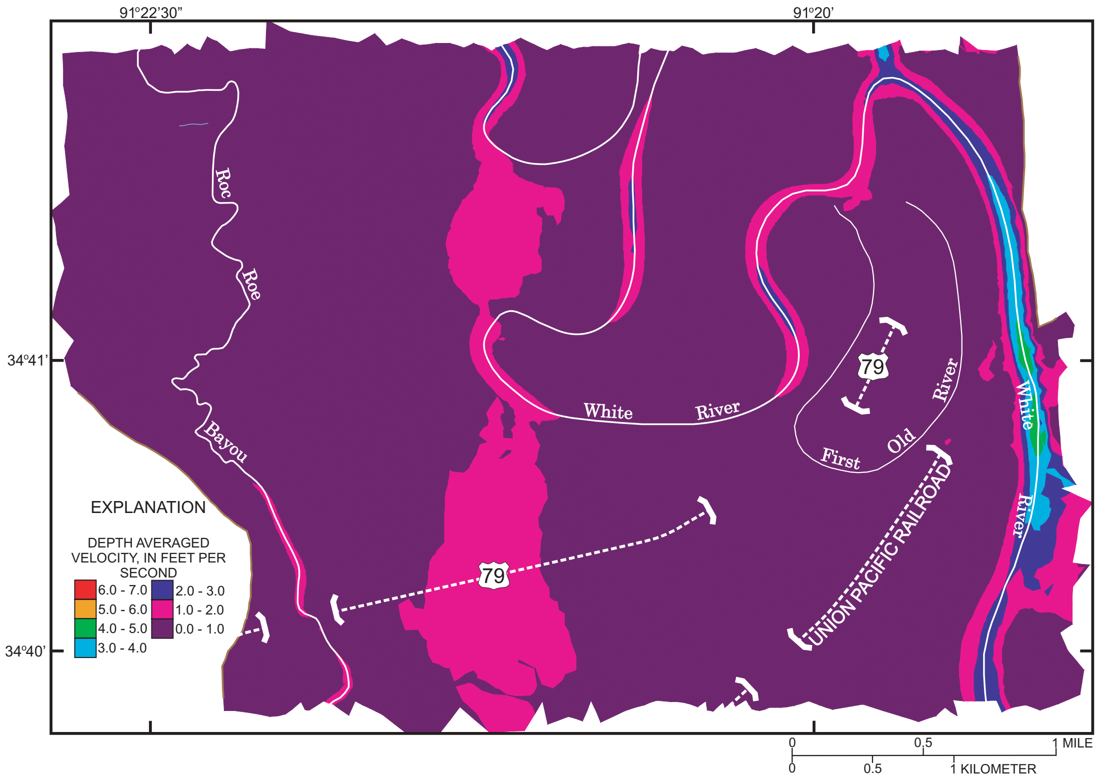

Figure 28. Depth-averaged velocity contours for the 100-year floodflow for natural conditions through the White River flood plain at the U.S. Highway 79 crossing (embankments are transparent as to illustrate flow through roadway for natural conditions).

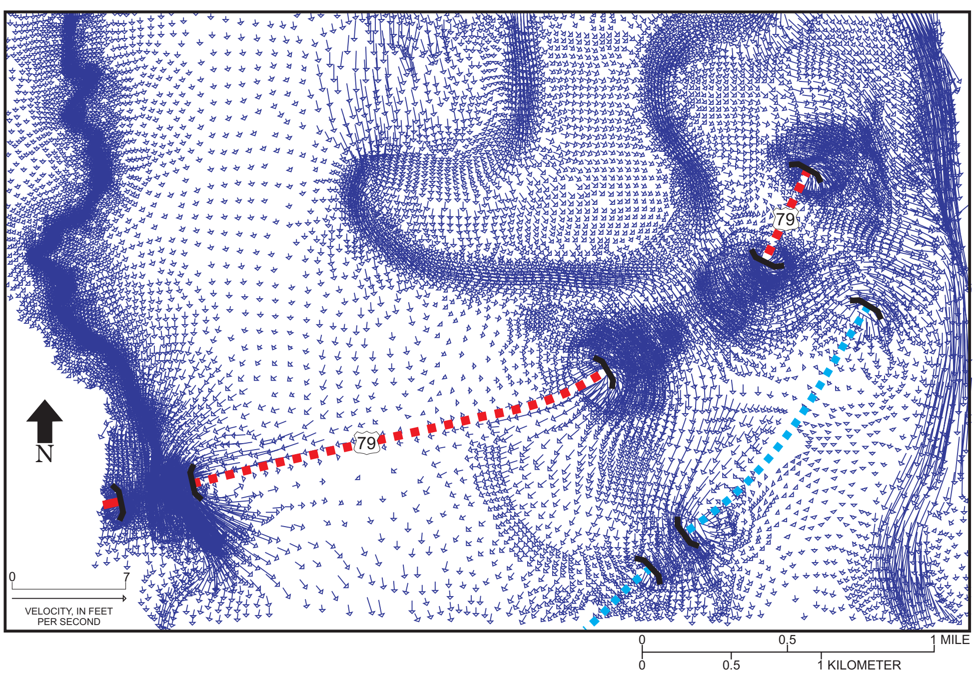

Figure 29. Distribution of depth-averaged point velocity vectors for the 100-year floodflow for natural conditions through the White River flood plain at the U.S. Highway 79 crossing (embankments are transparent as to illustrate flow through roadway for natural conditions).

bridge opening increase moderately compared to existing conditions (table 5). Water-surface elevations range from 175.6 ft to 175.9 ft through the bridge openings (fig. 30), and the maximum depth averaged point velocities occur around the bridge abutments for each opening (figs. 31-32, table 5).

The average backwater caused by the proposed Alternative 1 U.S. Highway 79 bridges was 0.6 ft for the 100-year floodflow. A complete tabulation of the hydraulic data for the 100-year floodflow for the bridges for proposed Alternative 1 is listed in table 5.

Proposed Conditions—Alternative 2

Simulation of the 100-year floodflow for the proposed Alternative 2 U.S. Highway 79 roadway alignment indicates that about 72 percent (155,600 ft^3/s) of the flow was conveyed by the proposed White River bridge, about 10 percent (20,700 ft^3/s) by the proposed 1,545-ft relief bridge, and about 17 percent (36,500 ft^3/s) by the proposed Roc Roe Bayou bridge (table 5). Although average velocities for Alternative 2 through each bridge opening were very similar to velocities through the bridge openings for existing conditions, the maximum point velocities through the White River bridge opening increase moderately compared to existing conditions (table 5). Water-surface elevations range from 175.6 ft to 176.0 ft through the bridge openings (fig. 33), and the maximum depth averaged point velocities occur around the bridge abutments for each opening (figs. 34-35, table 5).

The average backwater caused by the proposed Alternative 2 U.S. Highway 79 bridges was 0.4 ft for the 100-year floodflow. A complete tabulation of the hydraulic data for 100-year floodflow for the bridges for proposed Alternative 2 is listed in table 5.

Proposed Conditions—Alternative 3

Simulation of the 100-year floodflow for the proposed Alternative 3 U.S. Highway 79 roadway alignment indicates that about 72 percent (155,100 ft^3/s) of the flow was conveyed by the proposed White River bridge, about 10 percent (20,600 ft^3/s) by the proposed 1,545-ft relief bridge, and about 17 percent (37,300 ft^3/s) by the proposed Roc Roe Bayou bridge (table 5). Although average velocities for Alternative 3 through each bridge opening were very similar to velocities through the bridge openings for existing conditions, the maximum point velocities through the White River

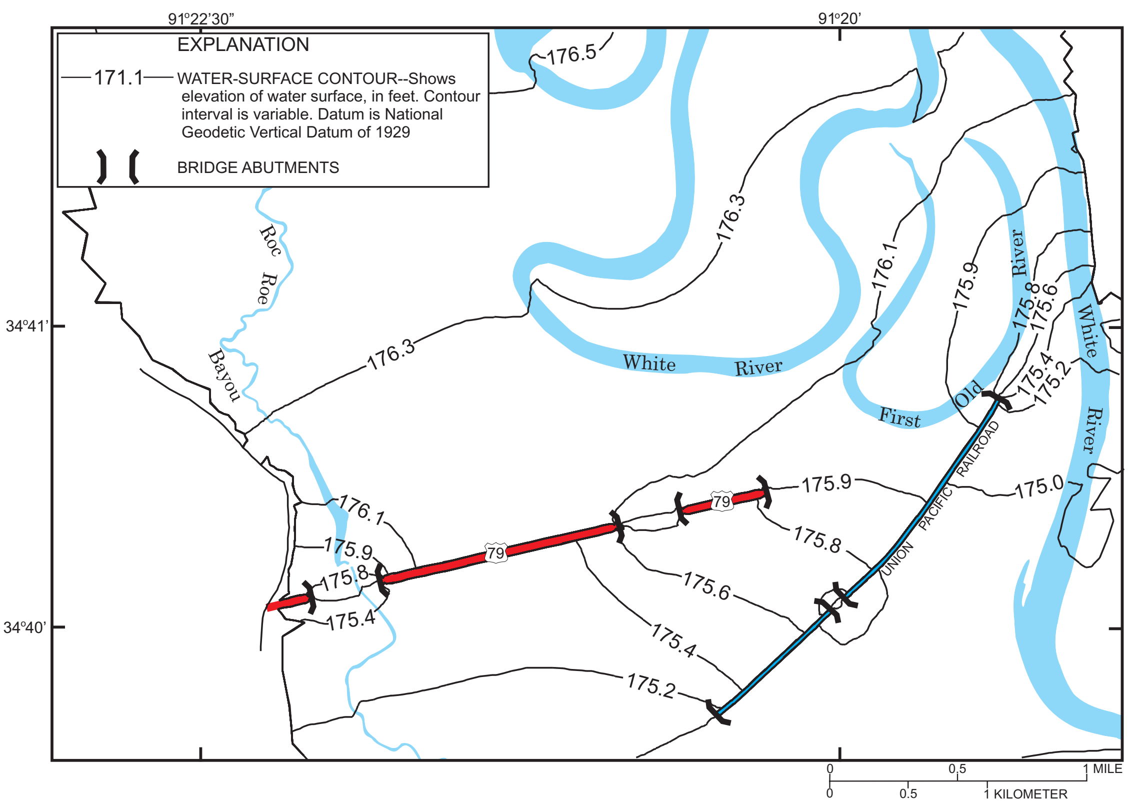

Figure 30. Simulated water-surface elevations for the 100-year floodflow through the proposed Alternative 1 U.S. Highway 79 roadway alignment.

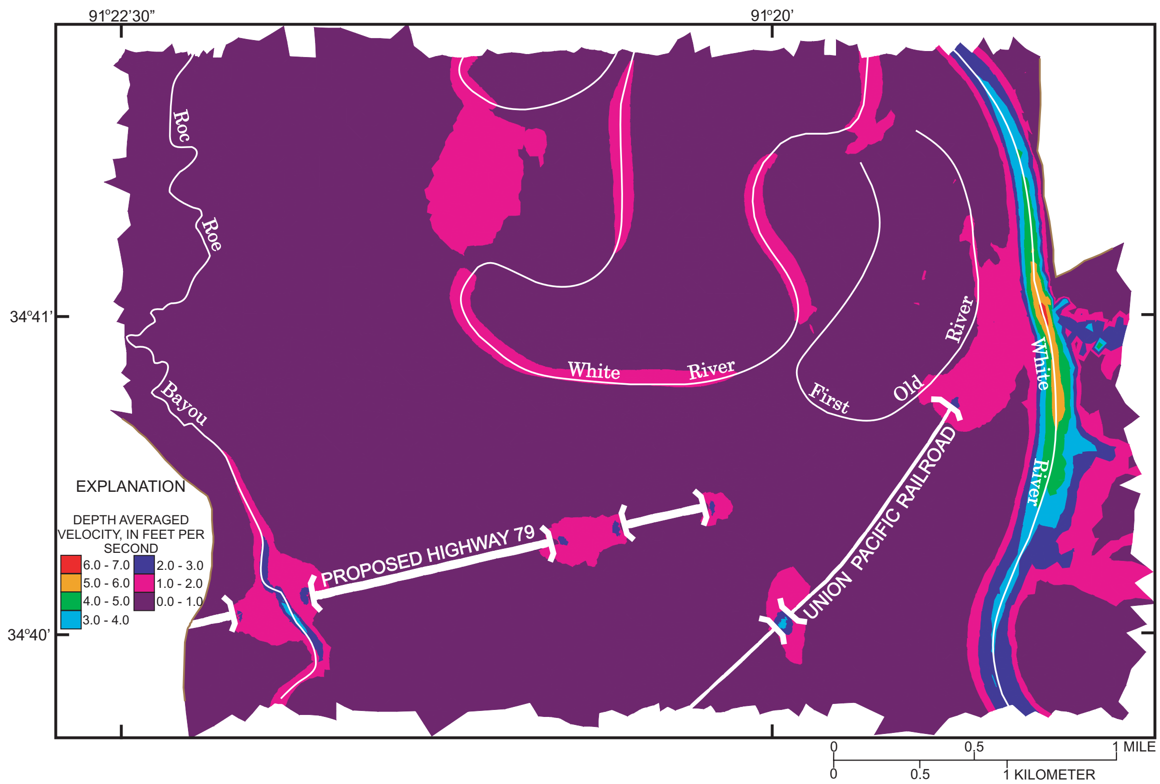

Figure 31. Depth-averaged velocity contours for the 100-year floodflow through the proposed Alternative 1 U.S. Highway 79 roadway alignment.

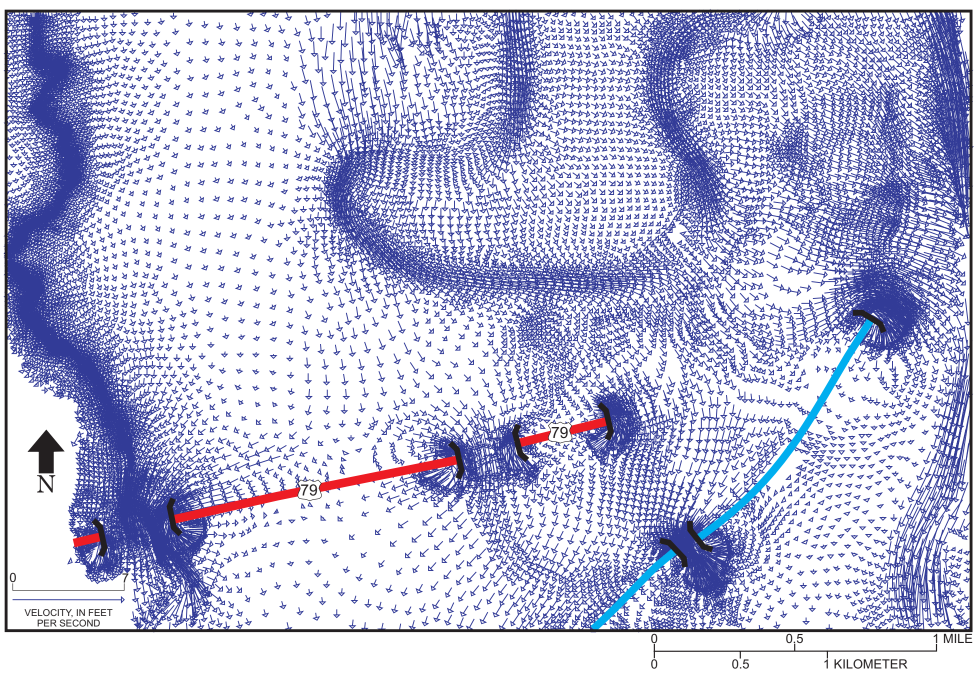

Figure 32. Distribution of depth-averaged point velocity vectors for the 100-year floodflow for the proposed Alternative 1 U.S. Highway 79 openings.

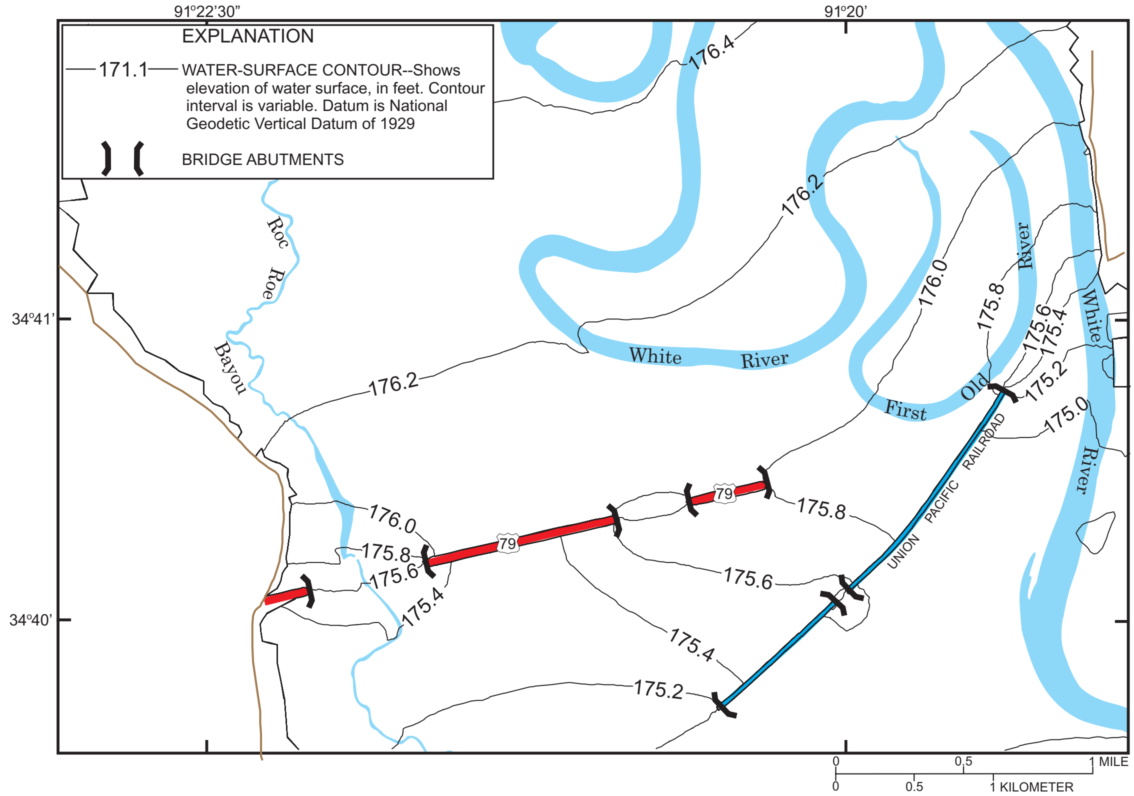

Figure 33. Simulated water-surface elevations for the 100-year floodflow through the proposed Alternative 2 U.S. Highway 79 roadway alignment.

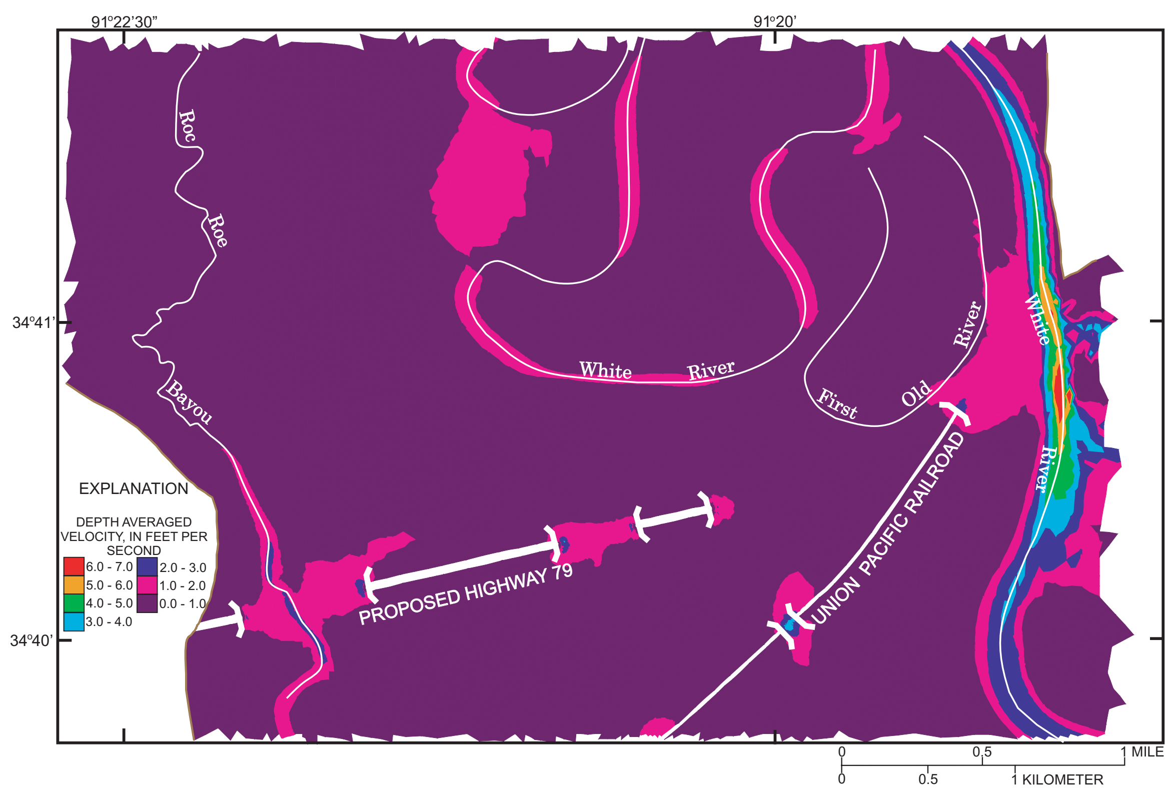

Figure 34. Depth-averaged velocity contours for the 100-year floodflow through the proposed Alternative 2 U.S. Highway 79 roadway alignment.

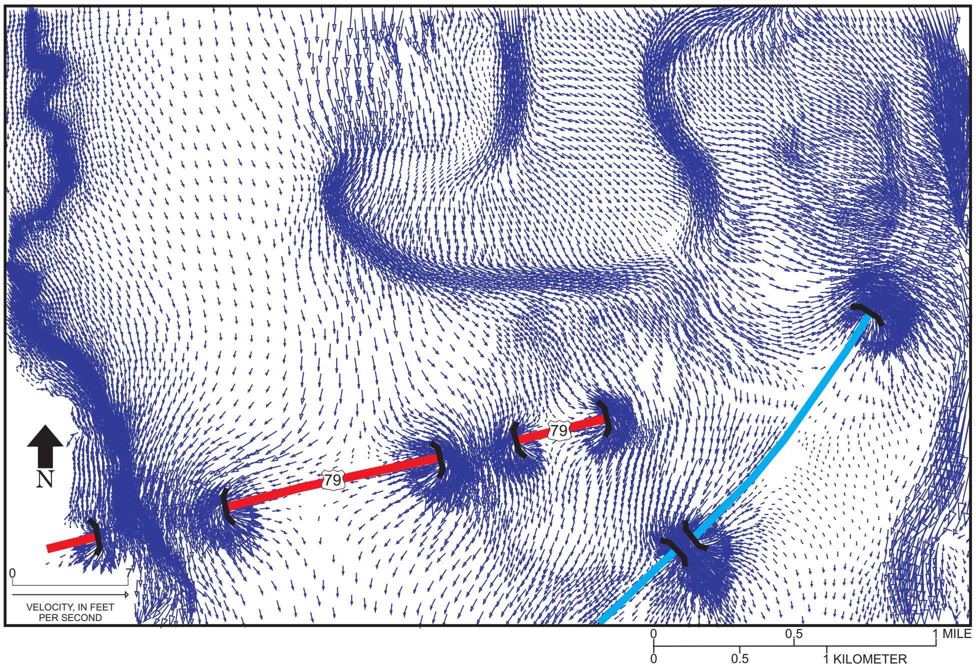

Figure 35. Distribution of depth-averaged point velocity vectors for the 100-year floodflow for the proposed Alternative 2 U.S. Highway 79 openings.

bridge opening increase moderately compared to existing conditions (table 5). Water-surface elevations range from 175.7 ft to 175.9 ft through the bridge openings (fig. 36), and the maximum depth averaged point velocities occur around the bridge abutments for each opening (figs. 37-38, table 5).

The average backwater caused by the proposed Alternative 3 U.S. Highway 79 bridges was 0.3 ft for the 100-year floodflow. A complete tabulation of the hydraulic data for the 100-year floodflow for the bridges for proposed Alternative 3 is listed in table 5.

Proposed Conditions—Alternative 4

Simulation of the 100-year floodflow for the proposed Alternative 4 U.S. Highway 79 roadway alignment indicates that about 70 percent (151,200 ft^3/s) of the flow was conveyed by the proposed White River bridge, about 9 percent (19,800 ft^3/s) by the proposed 1,545-ft relief bridge, and about 20 percent (43,000 ft^3/s) by the proposed Roc Roe Bayou bridge (table 5). Although average velocities for Alternative 4 through each bridge opening were very similar to velocities through the bridge openings for existing conditions, the maximum point velocities through the White River bridge opening increase moderately compared to existing conditions (table 5). Water-surface elevations range from 175.6 ft to 175.8 ft through the bridge openings (fig. 39), and the maximum depth averaged point velocities occur around the bridge abutments for each opening (figs. 40-41, table 5).

The average backwater caused by the proposed Alternative 4 U.S. Highway 79 bridges was 0.3 ft for the 100-year floodflow. A complete tabulation of the hydraulic data for the 100-year floodflow for the bridges for proposed Alternative 4 is listed in table 5.

Comparison of Simulation Results for Proposed Alternatives and Existing Conditions

Simulation results indicate relatively little difference in the changes in backwater elevation and velocities among the four alternatives during the 100-year recurrence interval floodflows (table 5). All of the alternatives typically result in slightly lower backwater elevations (0.2 to 0.5 foot lower), average velocities (0.2 to 1.1 ft/s lower), and maximum velocities (about 1 to 2 ft/s lower) across Roc Roe Bayou bridge and higher maximum velocities (about 1 ft/s) across the White River bridge, than for existing conditions. However, as table 5 illustrates, these differences are relatively small and the locations of the maximum depth averaged point velocity does not change between each alternative and existing bridge openings. A comparison of backwater and velocity for each alternative to existing conditions is shown in table 6.

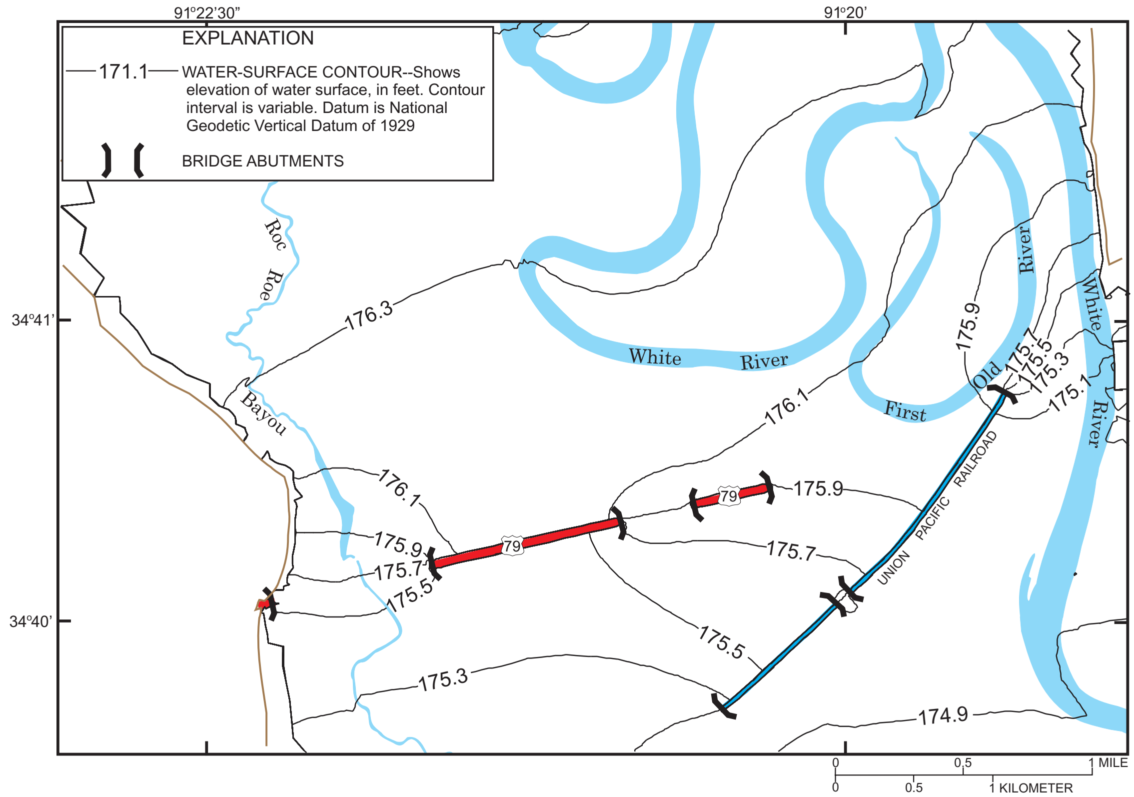

Figure 36. Simulated water-surface elevations for the 100-year floodflow through the proposed Alternative 3 U.S. Highway 79 roadway alignment.

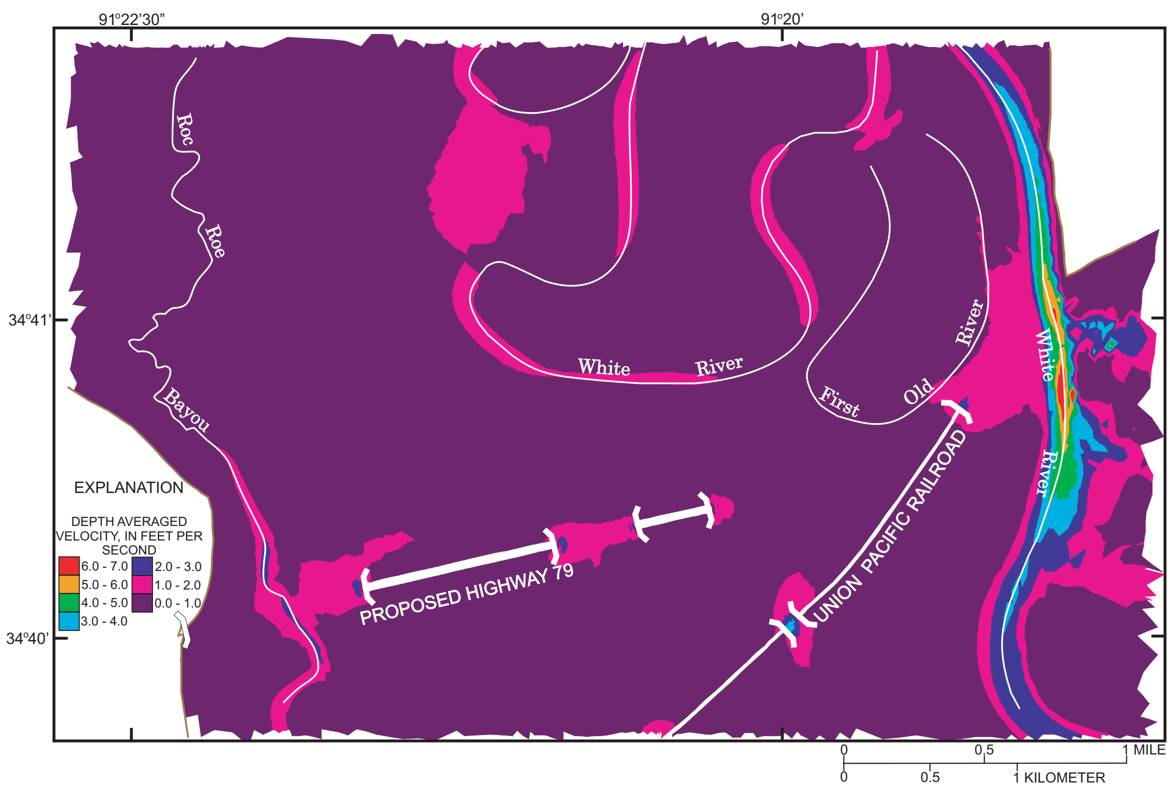

Figure 37. Depth-averaged velocity contours for the 100-year floodflow through the proposed Alternative 3 U.S. Highway 79 roadway alignment.

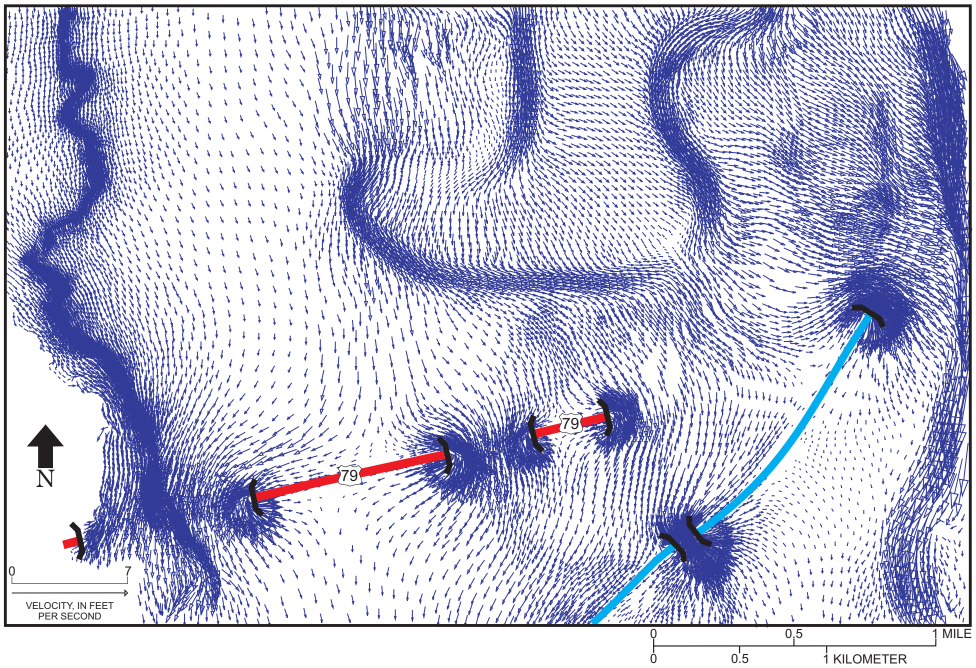

Figure 38. Distribution of depth-averaged point velocity vectors for the 100-year floodflow for the proposed Alternative 3 U.S. Highway 79 openings.

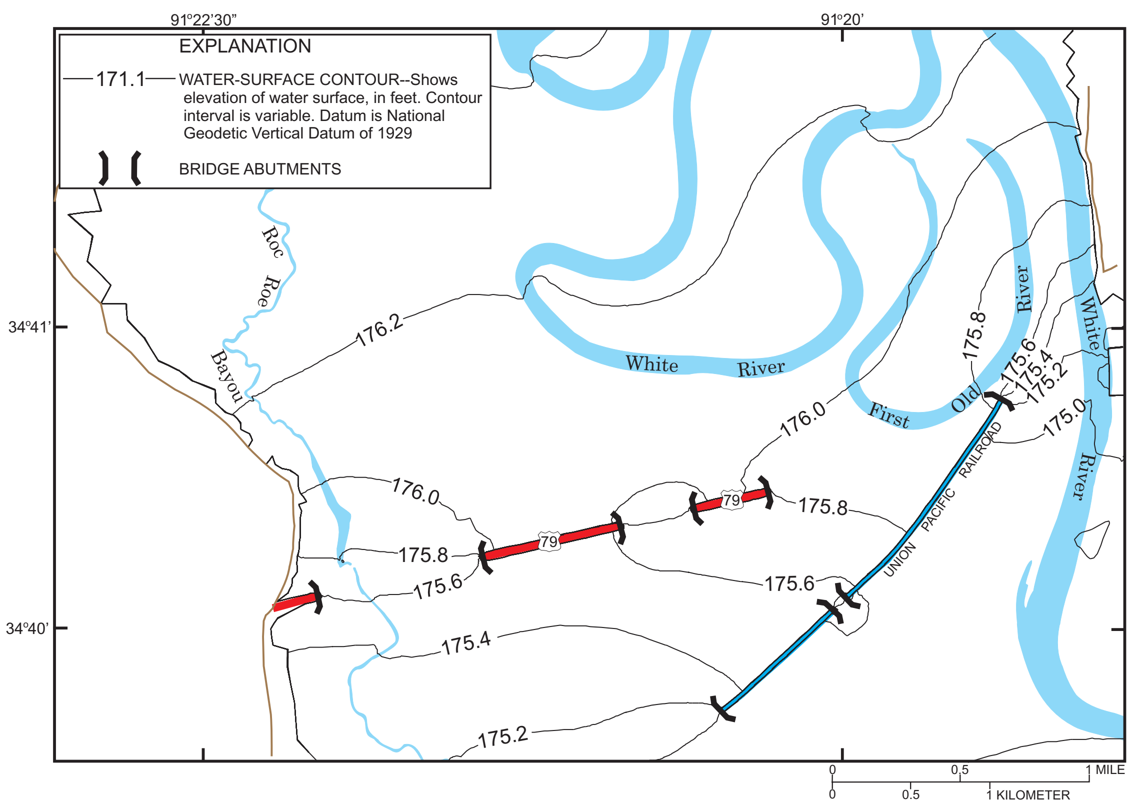

Figure 39. Simulated water-surface elevations for the 100-year floodflow through the proposed Alternative 4 U.S. Highway 79 roadway alignment.

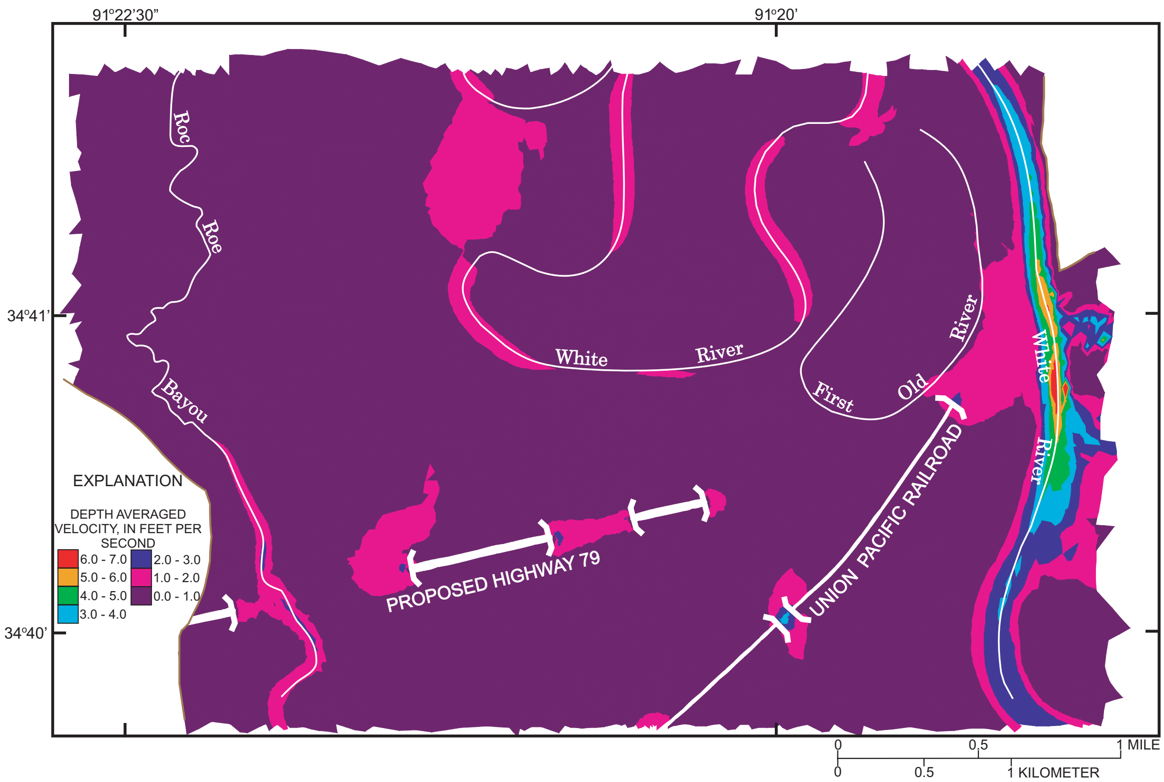

Figure 40. Depth-averaged velocity contours for the 100-year floodflow through the proposed Alternative 4 U.S. Highway 79 roadway alignment.

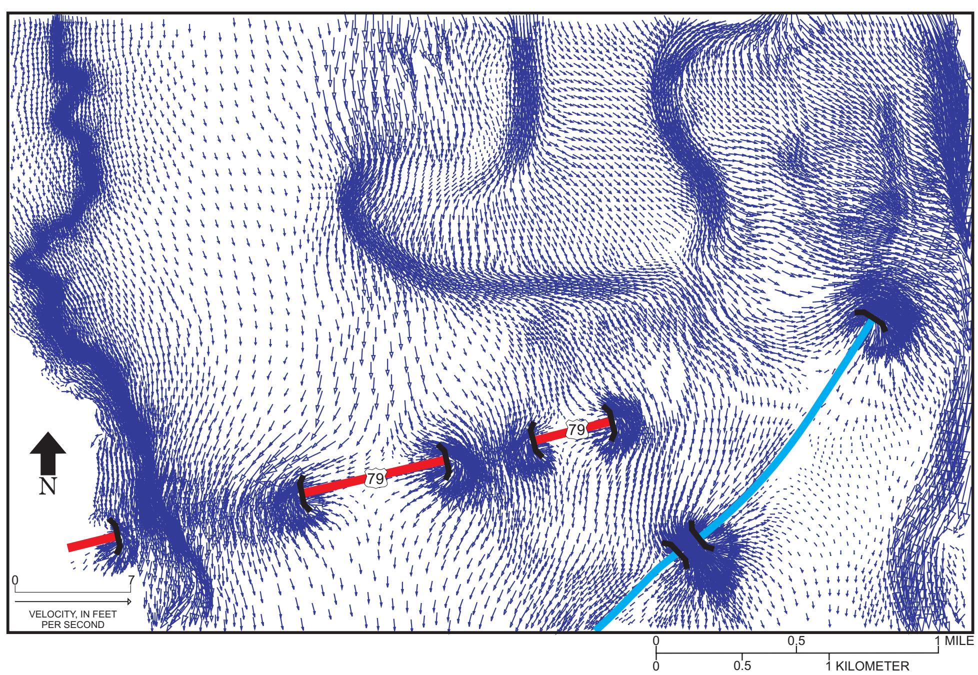

Figure 41. Distribution of depth-averaged point velocity vectors for the 100-year floodflow for the proposed Alternative 4 U.S. Highway 79 openings.

Table 6. Comparison of backwater and velocity data for each alternative to existing conditions for simulated floodflows having a 100-year recurrence interval

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Change in backwater elevation (in feet)	-0.2	-0.4	-0.5	-0.5
Change in average velocity across White River bridge (in feet per second)	-0.2	-0.3	-0.3	-0.3
Change in average velocity across Roc Roe Bayou bridge (in feet per second)	-0.4	-0.7	-1.1	-1.0
Change in maximum velocity across White River bridge (in feet per second)	+1.2	+1.2	+1.1	+0.9
Change in maximum velocity across Roc Roe Bayou bridge (in feet per second)	-1.2	-1.7	-1.7	-2.0

SUMMARY

A two-dimensional finite-element surface-water model was used to study the effects of the proposed modification to the U.S. Highway corridor 79 on flooding on the White River near Clarendon, Arkansas. The effects of floodflow were simulated for the following: existing conditions, natural conditions, and four proposed bridging alternatives. All of the scenarios were modeled with floods having the 5- and 100-year recurrence intervals (115,100 and 216,000 ft^3/s). The simulated existing conditions included a 3,200-ft White River bridge located on the east side of the study area near Clarendon, Arkansas; a 3,700-ft First Old River bridge located 0.5 mi west of the White River bridge opening; and a 1,430-ft Roc Roe Bayou bridge located 1.6 mi west of the First Old River bridge. The simulated hypothetical natural conditions involved removing the U.S. Highway 79 and the Union Pacific Railroad embankments along the entire length of the flood plain. The primary purpose of model simulations for natural conditions was to calculate backwater data for the existing and proposed conditions. The four simulated hypothetical proposed alternatives involved a 1.8-mi White River bridge located on the east side of the study area near Clarendon, Arkansas; and either an Alternative 1 with a 1,400-foot relief bridge or Alternatives 2-4 with a 1,545 relief bridge located 0.25 mi west of the White River bridge opening; and three different Roc Roe Bayou bridge openings ranging from 1,540-3,475 ft in length located 0.9 mi west of the relief bridge.

Simulation of the 5-year floodflow for the existing conditions indicates that about 57 percent (65,600 ft^3/s) of flow was conveyed by the White River bridge, about 26 percent (29,900 ft^3/s) by the First Old River bridge, and about 17 percent (19,600 ft^3/s) by the Roc Roe Bayou bridge. Maximum depth-averaged point velocities for the White River and First Old River bridges were 3.6 and 1.6 ft/s, respectively. Average depths were 12 and 10 ft for the White River and First Old River bridges, respectively. The maximum depth-averaged point velocity predicted for the Roc Roe Bayou bridge was 3.3 ft/s with an average depth of 8 ft. The average water-surface elevation at the upper boundary of the study area was 171.9 ft; the average water-surface elevation along U.S. Highway 79 was 171.5 ft; and the average water-surface elevation at lower boundary of the study area was set at 168.5 ft. Average depths at the upper boundary, U.S. Highway 79, and the lower boundary were 11 ft, 10 ft, and 10 ft, respectively.

Simulation of the 5-year floodflow for the proposed U.S. Highway 79 alignment alternatives indicates that 76-78 percent (87,100-89,900 ft^3/s) of the flow was conveyed by the proposed White River bridge, 6-7 percent (7,000-7,500 ft^3/s) by the proposed relief bridge, and 13-16 percent (14,600-18,600 ft^3/s) by the proposed Roc Roe Bayou bridge.

Simulation results indicate relatively little difference in the change in backwater elevation and velocities among the four alternatives during the 5-year recurrence interval floodflows. Alternative 1 typically resulted in slightly higher backwater elevation (about 0.1 foot), lower average velocity (0.1 to 0.6 ft/s), higher maximum velocity across the White River bridge opening (about 1 ft/s) and a lower maximum velocity across the Roc Roe Bayou bridge opening (about 0.4 ft/s) than for the existing bridge openings. Alternatives 2, 3, and 4 typically result in slightly lower backwater elevation (about 0.2 ft), lower average velocities (0.2 to 0.7 ft/s), higher maximum velocities (0.8 to 0.9 ft/s) across the White River bridge opening, and lower maximum velocities (1.0 to 1.3 ft/s) across the Roc Roe Bayou bridge opening than for existing conditions. However, these differences are relatively small and the locations of the maximum depth averaged point velocity does not change between each alternative and existing bridge openings.

Simulation of the 100-year floodflow for existing conditions indicates that about 56 percent (123,100 ft^3/s) of flow was conveyed by the White River bridge, about 26 percent (56,200 ft3/s) by the First Old River bridge, and about 19 percent (41,000 ft^3/s) by the Roc Roe Bayou bridge. The maximum depth-averaged point velocities for the White River and First Old River bridges were 4.2 and 2.2 ft/s, respectively. Average depths were 16 and 15 ft for the White River and First Old River bridges, respectively. The maximum depth-averaged point velocity predicted for the Roc Roe Bayou bridge was 4.1 ft/s with an average depth of 13 ft. The average water-surface elevation at the upper boundary of the study area was 176.9 ft; the average water-surface elevation along U.S. Highway 79 was 176.3 ft; and the average water-surface elevation at the lower boundary of the study area was set at 173.21 ft. Average depths at the upper boundary, U.S. Highway 79, and the lower boundary were 15, 14, and 14 ft, respectively.

Simulation of the 100-year floodflow for the proposed U.S. Highway 79 alignment alternatives indicates that 70-72 percent (151,200-155,600 ft^3/s) of the flow was conveyed by the proposed White River bridge, 9-10 percent (19,800-20,700 ft^3/s) by the proposed relief bridge, and 14-20 percent (30,700-43,000 ft^3/s) by the proposed Roc Roe Bayou bridge. Simulation results indicate relatively little difference in the changes in backwater elevation and velocities among the four alternatives during the 100-year recurrence interval floodflows. All of the alternatives typically result in slightly lower backwater elevations (0.2 to 0.5 ft lower) and average velocities (0.2 to 1.1 ft/s lower) than for existing conditions. Maximum velocities across Roc Roe Bayou bridge decreased (1.2 to 2.0 ft/s) and across White River bridge increased (0.9 to 1.2 ft/s) when compared to existing conditions. However, these differences are relatively small and the locations of the maximum depth averaged point velocity does not change between each alternative and existing bridge openings.

REFERENCES

Froehlich, D.A., 1989, Finite element surface-water modeling system, Two dimensional flow in a horizontal plane-Users manual: U.S. Department of Transportation Publication No. FHWA-RD-88-187, 285 p.

Brigham Young University, 1999, SMS Surface-water modeling system—Reference manual—Version 6.0: Provo, Utah, Environmental Modeling Research Laboratory, 340 p.

Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: Hydrology Subcommittee, 183 p.

Lee, J.K., and Froehlich, D.A., 1989, Two-dimensional finite-element hydraulic modeling of bridge crossings—Research report: U.S. Department of Transportation Publication No. FHWA-RD-88-146, 256 p.

Sullavan, J.N., 1974, Drainage areas of streams in Arkansas: U.S. Geological Survey Open-File Report, 123 p.

Funkhouser, J.E., and Barks, C.S.—SIMULATIONS OF FLOODFLOWS ON THE WHITE RIVER IN THE VICINITY OF U.S. HIGHWAY 79 NEAR CLARENDON, ARKANSAS—U.S. Geological Survey Water-Resources Investigations Report 02-4256