Hydraulic Analyses of Alternative Methods for Reducing Backwater from Log Jams on Locust Creek near Pershing State Park, Linn County, Missouri

By Terry W. Alexander

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ABSTRACT

Since 1993, flooding has caused extensive accumulations of sediment and log debris within the main channel of Locust Creek near Pershing State Park, Linn County, Missouri. In response to concerns about means of mitigating the current (1997) backwater problems, a one-dimensional surface-water flow model was used to evaluate four alternative methods for improving the flow characteristics of Locust Creek in the vicinity of Pershing State Park.

Compared with the existing (1996–97) channel conditions, the four alternative methods gave maximum reductions in water-surface elevations upstream from State Highway 36 ranging from 2.18 feet (alternatives 1 and 2) to 6.33 feet (alternative 4). The computed bankfull discharges of Locust Creek for each of the four alternative methods indicate an increase in flow capacities ranging from 975 cubic feet per second (alternative 2) to 3,500 cubic feet per second (alternative 4) when compared with existing (1996–97) conditions with the log jams in place.

INTRODUCTION

Locust Creek has been channelized and leveed for most of its 80-mile length upstream (north) from Pershing State Park in Linn County, Missouri (fig. 1). However, Locust Creek returns to its naturally sinuous channel in Pershing State Park. Because the park retains the quality of an undisturbed, presettlement landscape and because of its outstanding natural features, the area has been officially designated a State natural area. The drainage area of Locust Creek at the State Highway 36 crossing is about 590 square miles.

Beginning with the 1993 flood and continuing with succeeding floods, Locust Creek has been choked with log jams near Pershing State Park. Immediately upstream from these log jams, Higgins Ditch, which flows parallel to and is in the same floodplain as Locust Creek, is receiving overbank flows from Locust Creek. Higgins Ditch may be scouring and widening because of overbank flows from Locust Creek, whereas Locust Creek is filling with sediment and woody debris and carrying less flow through the park. Decreased flow (backwater) in Locust Creek and increased flow in Higgins Ditch threatens to change the native ecosystem in the Pershing State Park area.

A possible solution of this problem is the removal of the log jams. To assist in determining theoretical water-surface-elevation profiles for the existing conditions and the proposed excavations of log jams in Locust Creek, the U.S. Geological

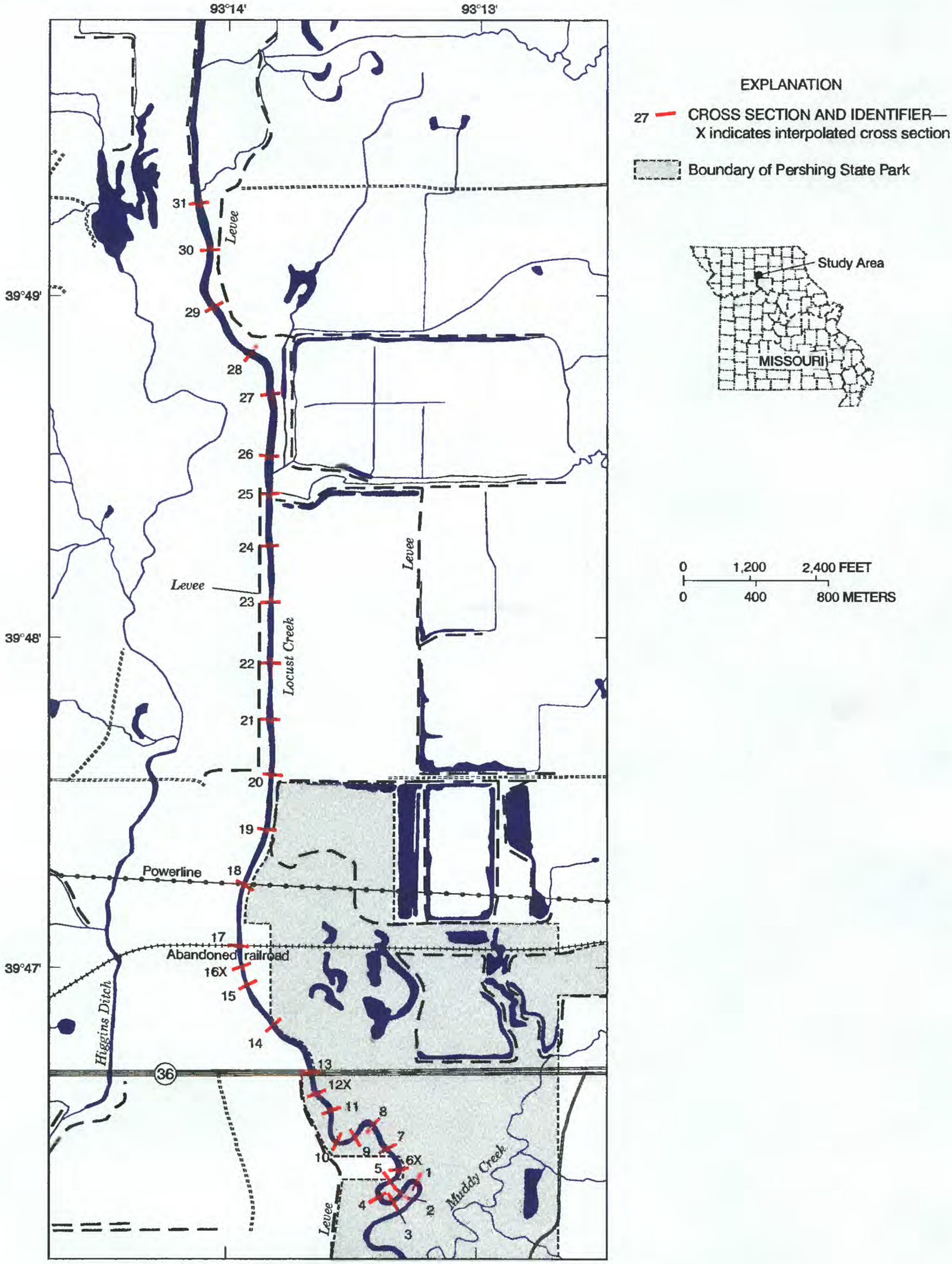

Figure 1. Location of Locust Creek in the vicinity of Pershing State Park.

Survey, in cooperation with the Missouri Department of Natural Resources, Division of State Parks, has completed a hydraulic study for Locust Creek in the vicinity of Pershing State Park. Results of this study will contribute to improved understanding of channelized and leveed streams.

OBJECTIVES

For the Locust Creek study reach (fig. 1), the hydraulic analyses (alternatives and use of a one-dimensional water-surface profile computation model) mutually agreed to by all agencies considered the following within-channel flow conditions:

1. Determine bankfull-flow and low-flow water-surface profiles for the existing main channel of Locust Creek and alternative 1 with minimal debris (100-percent excavated opening with 3:1 bank slopes) from State Highway 36 to upstream from the abandoned railroad crossing (cross sections 13–18).

2. Determine water-surface profiles for a 35-foot (about 30-percent excavated channel, alternative 2), 70-foot (about 60-percent excavated channel, alternative 3), and 100-percent excavated channel (alternative 4) with 3:1 bank slopes from cross section 1 through 18.

3. Determine discharges that will result in bankfull water-surface elevations on the main channel of Locust Creek for each of the four alternatives. These discharges will indicate the increase in flow capacity of the main channel compared to existing conditions with the log jams in place.

HYDRAULIC DATA

Cleaver and Associates (written commun., 1997) provided the vertical control and channel geometry for the 13 cross sections (1–13) downstream from State Highway 36 (fig. 1). Also, 18 additional cross sections (14–31) were transit-stadia surveyed upstream from State Highway 36. All cross sections were surveyed perpendicular to the assumed direction of flow and are considered valid sections for the existing and proposed study-reach excavations. The flow distances used to compute subreach friction losses between cross sections are referenced from the downstream cross section 1 at stationing 0 feet.

WATER-SURFACE COMPUTATIONS

A one-dimensional computer model for Water-Surface PROfile computations (WSPRO; Shearman, 1990) was selected for simulating water-surface elevations on Locust Creek in the vicinity of Pershing State Park. The WSPRO computer model roughness coefficient parameters were adjusted to simulate as close as possible (best fit) the March 12, 1997, water-surface profile. These roughness coefficients were used in this study to predict water-surface elevations for the existing channel and the proposed excavations of log jams. Roughness coefficients used in the WSPRO analyses ranged from 0.035 to 0.060. The roughness coefficients were adjusted during the analyses on the basis of hydraulic depth and on the basis of channel subdivisions.

The study emphasis was to compute water-surface profiles along the Locust Creek study reach for both the existing and alternative channel conditions (figs. 2–6). The WSPRO simulated water-surface elevations for existing conditions and the four alternative log-jam-excavation conditions are given in tables 1 through 5, at the back of this report. The four alternatives showed maximum reductions in water-surface elevations (backwater) upstream from State Highway 36 ranging from 2.18 feet (alternatives 1 and 2) to 6.33 feet (alternative 4). Computed bankfull water-surface elevations and discharges for the four alternative excavation conditions are listed in the two right-hand columns in tables 1 and 3 through 5 (water-surface profiles are not shown for these elevations). Bankfull discharges for the four alternatives indicate an increase in Locust

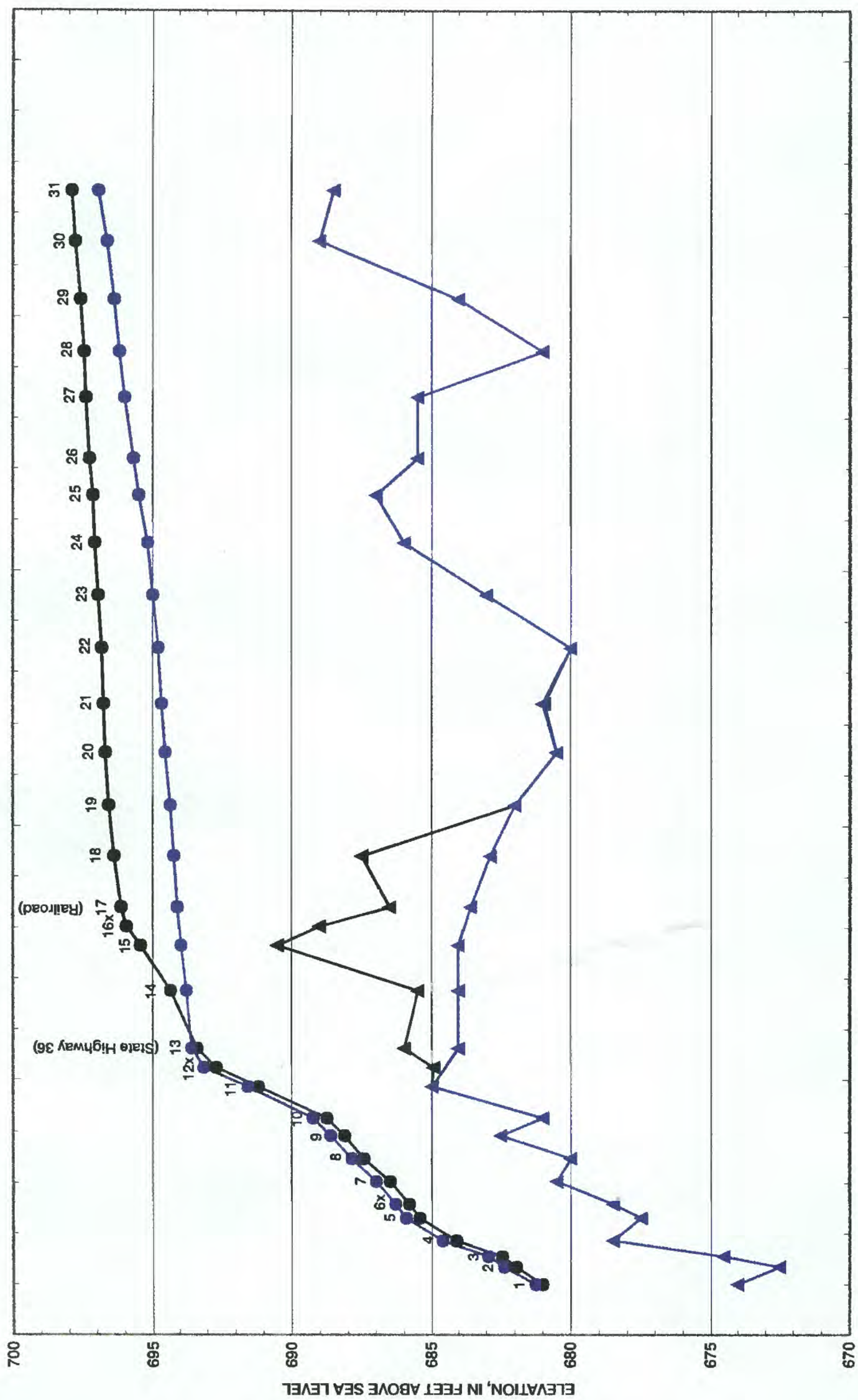

Figure 2. Locust Creek water-surface profiles for the existing channel and alternative 1—a 100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing (cross sections 13–18).

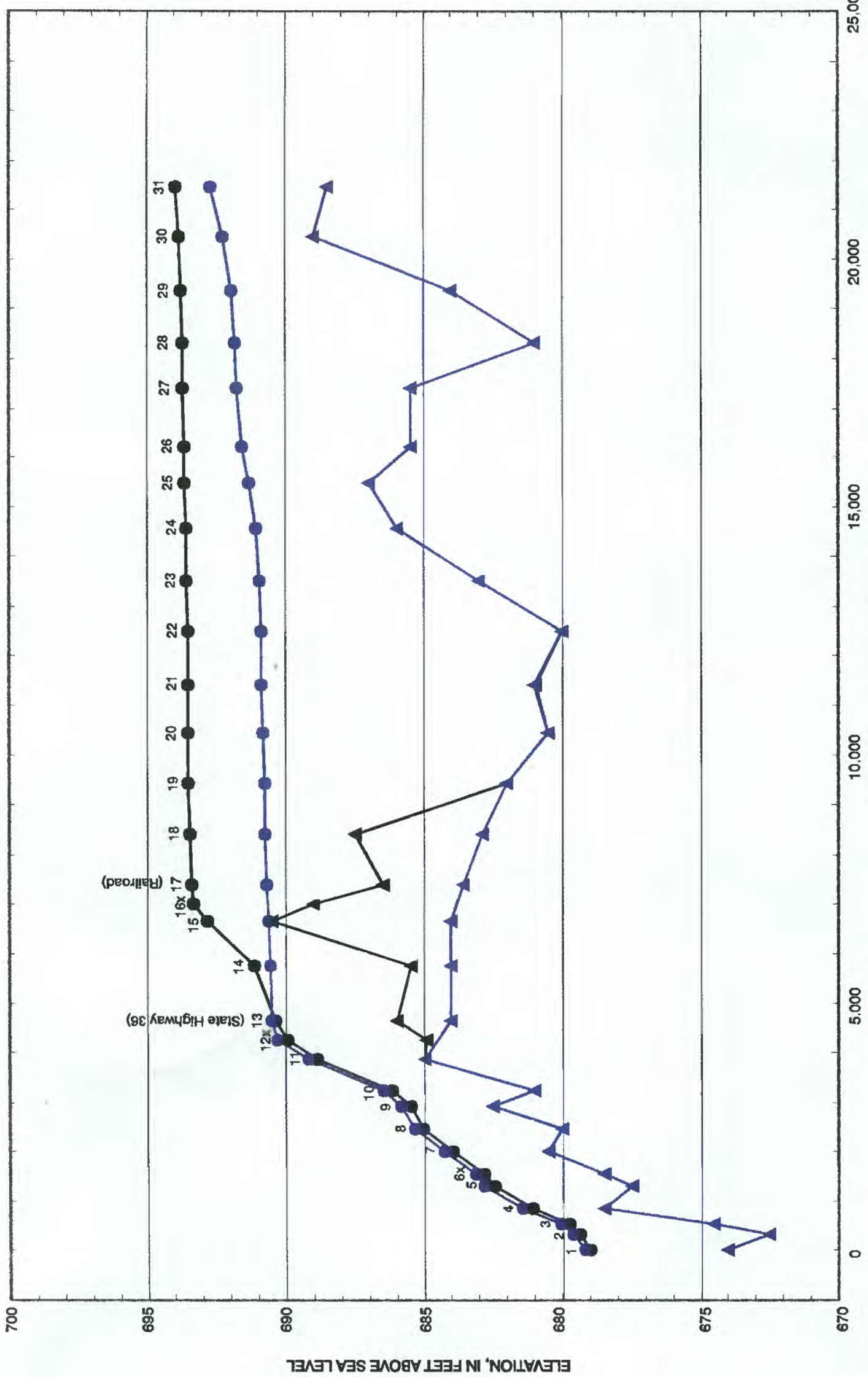

Figure 3. Locust Creek low-flow water-surface profiles for the existing channel and alternative 1—a 100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing (cross sections 13–18).

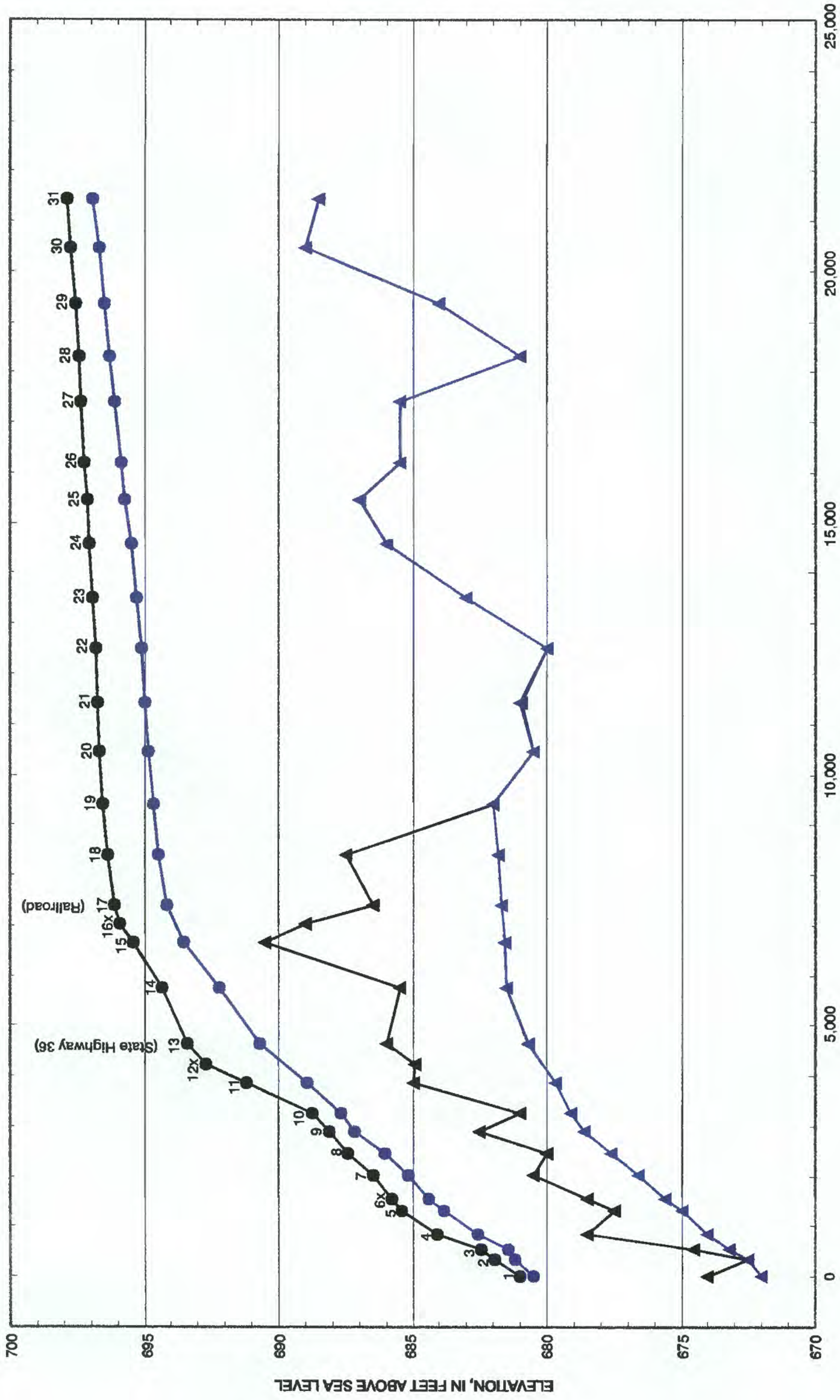

Figure 4. Locust Creek water-surface profiles for the existing channel and alternative 2—a 35-foot excavated channel (cross sections 1–18).

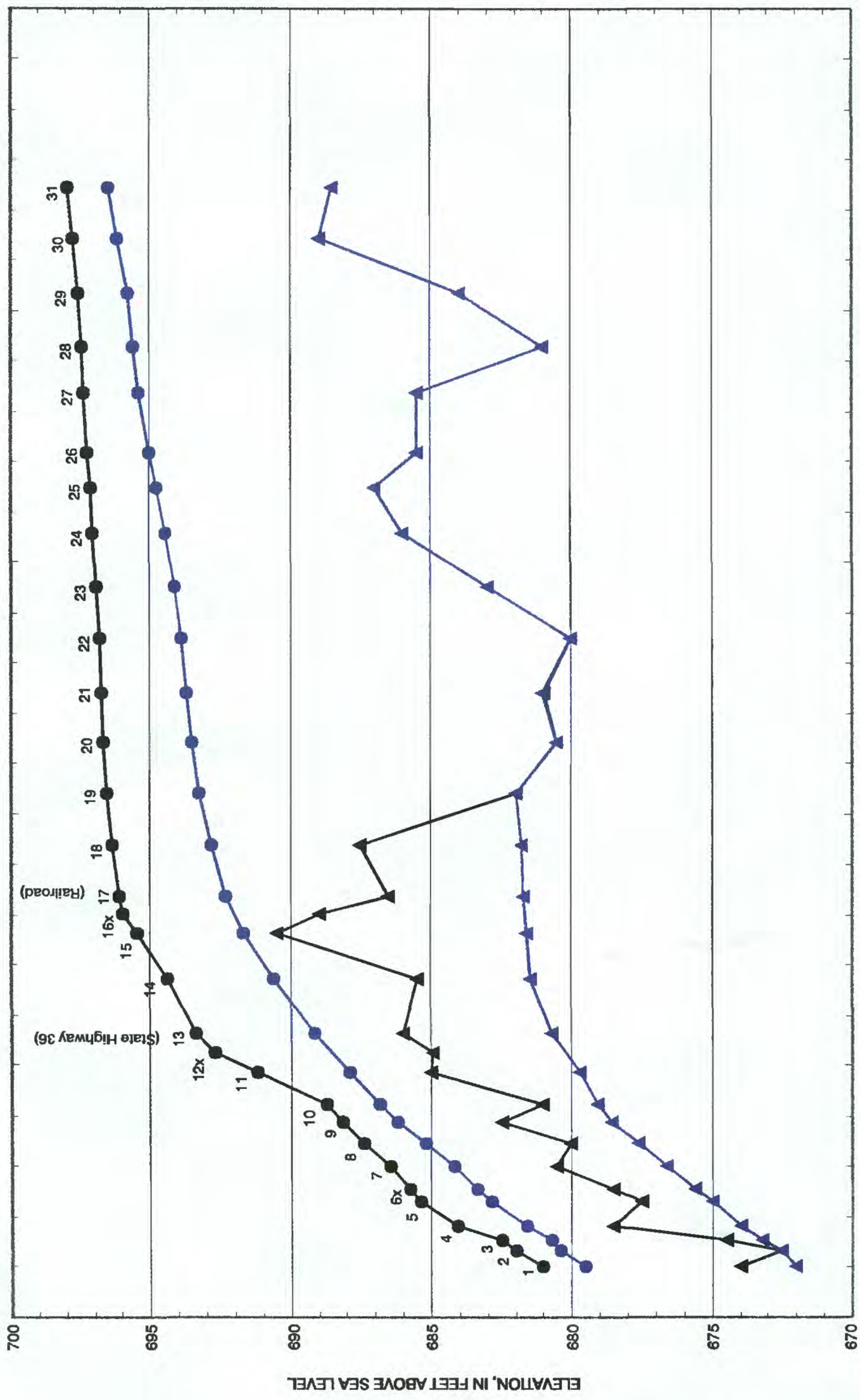

Figure 5. Locust Creek water-surface profiles for the existing channel and alternative 3—a 70-foot excavated channel (cross sections 1–18).

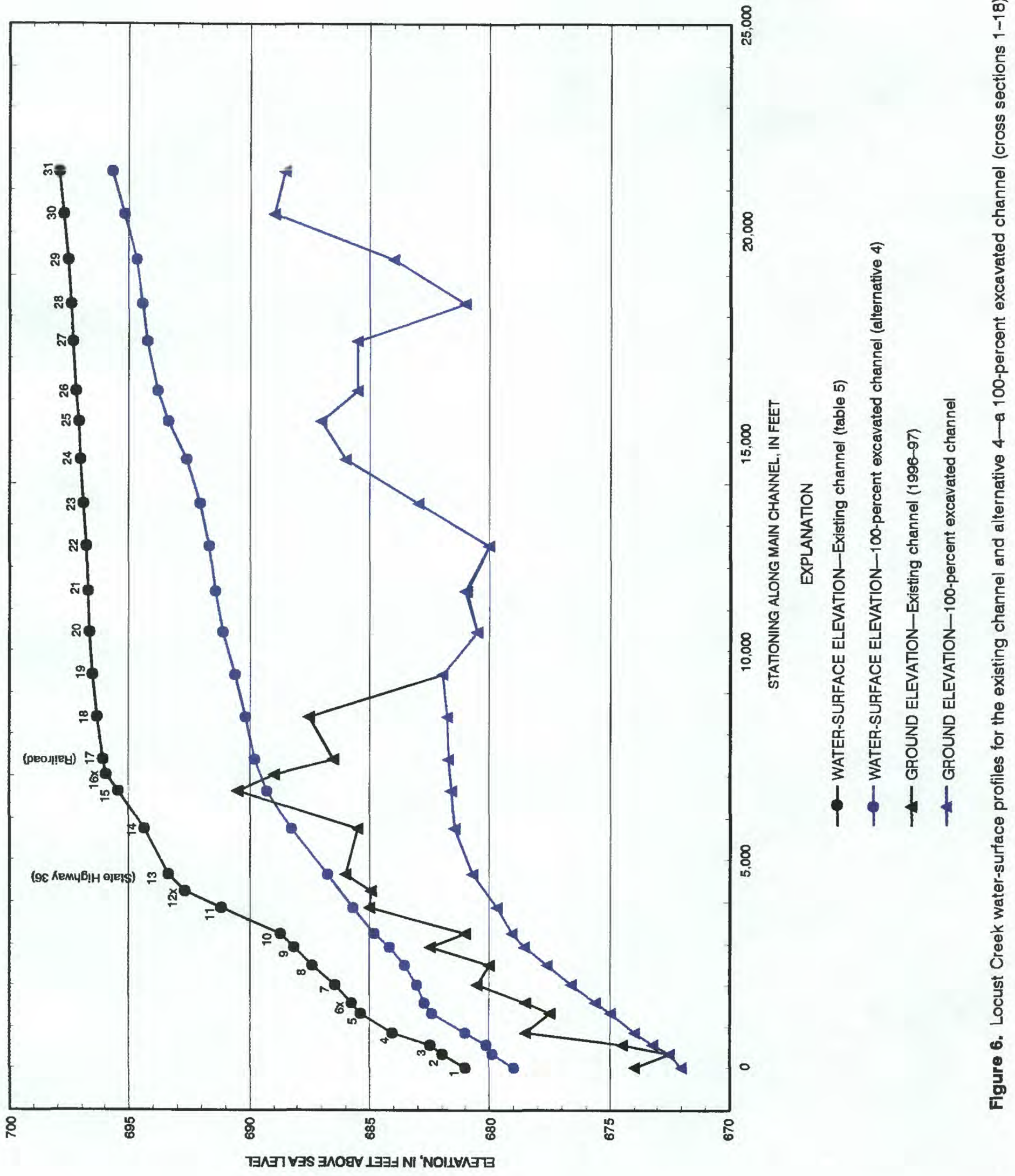

Figure 6. Locust Creek water-surface profiles for the existing channel and alternative 4—a 100-percent excavated channel (cross sections 1–18).

Creek flow capacities ranging from 975 cubic feet per second (alternative 2) to 3,500 cubic feet per second (alternative 4). These results can be used by planners, designers, and engineers to aid in determining what effect the proposed modifications will have at various locations along the Locust Creek study reach.

REFERENCE CITED

Shearman, J.O., 1990, User's manual for WSPRO—A computer model for water surface profile computations: U.S. Department of Transportation Publication No. FHWA–IP–89–027 Hydraulic Computer Programs HY-7, 177 p.

Table 1. Locust Creek water-surface elevations for the existing channel and alternative 1—a 100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing (cross sections 13–18)

[ft, feet; ft^3/s, cubic feet per second; --, no data]

Cross section (fig. 1)		Existing channel			100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 2)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 2)	Discharge (ft^3/s)	Water-surface elevation (ft)
1	0	1,500	681.00	--	1,775	681.25	2,750	682.50
2	330	1,500	681.96	--	1,775	682.38	2,750	683.90
3	540	1,500	682.48	--	1,775	682.94	2,750	684.48
4	840	1,500	684.07	--	1,775	684.62	2,750	686.33
5	1,315	1,500	685.38	--	1,775	685.92	2,750	687.59
6X	1,565	1,500	685.76	--	1,775	686.31	2,750	688.00
7	2,015	1,500	686.47	--	1,775	687.00	2,750	688.63
8	2,475	1,500	687.39	--	1,775	687.89	2,750	689.44
9	2,910	1,500	688.12	--	1,775	688.64	2,750	690.19
10	3,250	1,500	688.72	--	1,775	689.25	2,750	690.73
11	3,875	1,500	691.19	--	1,775	691.55	2,750	692.69
12X	4,255	1,500	692.69	--	1,775	693.15	2,750	694.41
13	4,635	1,500	693.37	694.0	1,775	693.58	2,750	694.95
14	5,750	1,500	694.36	695.0	1,775	693.77	2,750	695.22
15	6,650	1,600	695.44	695.5	1,825	693.96	2,850	695.49
16X	7,025	1,650	695.94	--	--	--	--	--
17	7,400	1,750	696.10	696.0	1,900	694.10	2,950	695.69

Table 1. Locust Creek water-surface elevations for the existing channel and alternative 1—a 100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing (cross sections 13–18)—Continued

Cross section (fig. 1)		Existing channel			100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 2)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 2)	Discharge (ft^3/s)	Water-surface elevation (ft)
18	8,400	1,900	696.34	696.5	1,950	694.23	3,000	695.87
19	9,420	1,950	696.54	696.5	1,950	694.36	3,000	696.06
20	10,450	1,950	696.65	697.0	1,950	694.53	3,000	696.30
21	11,415	1,950	696.72	697.5	1,950	694.64	3,000	696.47
22	12,425	1,950	696.80	698.0	1,950	694.78	3,000	696.67
23	13,525	1,950	696.91	698.0	1,950	694.96	3,000	696.93
24	14,575	1,950	697.02	698.5	1,950	695.18	3,000	697.20
25	15,475	1,950	697.12	698.5	1,950	695.46	3,000	697.51
26	16,200	1,950	697.21	699.5	1,950	695.68	3,000	697.75
27	17,400	1,950	697.35	699.5	1,950	695.97	3,000	698.07
28	18,300	1,950	697.44	700.0	1,950	696.14	3,000	698.27
29	19,350	1,950	697.56	700.5	1,950	696.33	3,000	698.48
30	20,450	1,950	697.72	701.0	1,950	696.62	3,000	698.77
31	21,450	1,950	697.89	702.0	1,950	696.91	3,000	699.06

Table 2. Locust Creek low-flow water-surface elevations for the existing channel and alternative 1—a 100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing (cross sections 13–18)

[ft, feet; ft^3/s, cubic feet per second; --, no data]

Cross section (fig. 1)		Existing channel			100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing	
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 3)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 3)
1	0	400	679.00	--	500	679.20
2	330	400	679.35	--	500	679.64
3	540	400	679.73	--	500	680.07
4	840	400	681.10	--	500	681.47
5	1,315	400	682.45	--	500	682.80
6X	1,565	400	682.80	--	500	683.17
7	2,015	400	683.97	--	500	684.29
8	2,475	400	685.02	--	500	685.32
9	2,910	400	685.49	--	500	685.82
10	3,250	400	686.16	--	500	686.48
11	3,875	400	688.88	--	500	689.20
12X	4,255	400	689.92	--	500	690.30
13	4,635	400	690.38	694.0	500	690.51
14	5,750	400	691.16	695.0	500	690.58
15	6,650	425	692.80	695.5	500	690.64
16X	7,025	450	693.33	--	--	--
17	7,400	475	693.38	696.0	525	690.69

Table 2. Locust Creek low-flow water-surface elevations for the existing channel and alternative 1—a 100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing (cross sections 13–18)—Continued

Cross section (fig. 1)		Existing channel			100-percent excavated channel from State Highway 36 to upstream from the abandoned railroad crossing	
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 3)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 3)
18	8,400	500	693.45	696.5	525	690.73
19	9,420	525	693.50	696.5	525	690.77
20	10,450	525	693.52	697.0	525	690.82
21	11,415	525	693.53	697.5	525	690.85
22	12,425	525	693.54	698.0	525	690.88
23	13,525	525	693.56	698.0	525	690.93
24	14,575	525	693.59	698.5	525	691.05
25	15,475	525	693.62	698.5	525	691.32
26	16,200	525	693.66	699.5	525	691.55
27	17,400	525	693.70	699.5	525	691.76
28	18,300	525	693.73	700.0	525	691.84
29	19,350	525	693.76	700.5	525	691.94
30	20,450	525	693.85	701.0	525	692.26
31	21,450	525	693.96	702.0	525	692.72

Table 3. Locust Creek water-surface elevations for the existing channel and alternative 2—a 35-foot excavated channel (cross sections 1–18)

[ft, feet; ft^3/s, cubic feet per second; --, no data]

Cross section (fig. 1)		Existing channel			35-ft excavated channel (cross sections 1–18)			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 4)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 4)	Discharge (ft^3/s)	Water-surface elevation (ft)
1	0	1,500	681.00	--	1,775	680.50	2,700	681.25
2	330	1,500	681.96	--	1,775	681.22	2,700	682.38
3	540	1,500	682.48	--	1,775	681.45	2,700	682.66
4	840	1,500	684.07	--	1,775	682.56	2,700	684.21
5	1,315	1,500	685.38	--	1,775	683.85	2,700	685.52
6X	1,565	1,500	685.76	--	1,775	684.39	2,700	686.02
7	2,015	1,500	686.47	--	1,775	685.15	2,700	686.69
8	2,475	1,500	687.39	--	1,775	686.05	2,700	687.53
9	2,910	1,500	688.12	--	1,775	687.14	2,700	688.70
10	3,250	1,500	688.72	--	1,775	687.67	2,700	689.30
11	3,875	1,500	691.19	--	1,775	688.94	2,700	690.63
12X	4,255	1,500	692.69	--	--	--	--	--
13	4,635	1,500	693.37	--	1,775	690.68	2,700	692.47
14	5,750	1,500	694.36	695.0	1,775	692.18	2,700	693.97
15	6,650	1,600	695.44	695.5	1,825	693.50	2,750	695.26
16X	7,025	1,650	695.94	--	--	--	--	--
17	7,400	1,750	696.10	696.0	1,900	694.14	2,850	695.91

Table 3. Locust Creek water-surface elevations for the existing channel and alternative 2—a 35-foot excavated channel (cross sections 1–18)—Continued

Cross section (fig. 1)		Existing channel			35-ft excavated channel (cross sections 1–18)			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 4)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 4)	Discharge (ft^3/s)	Water-surface elevation (ft)
18	8,400	1,900	696.34	696.5	1,950	694.44	2,900	696.25
19	9,420	1,950	696.54	696.5	1,950	694.68	2,925	696.53
20	10,450	1,950	696.65	697.0	1,950	694.84	2,925	696.75
21	11,415	1,950	696.72	697.5	1,950	694.96	2,925	696.91
22	12,425	1,950	696.80	698.0	1,950	695.09	2,925	697.10
23	13,525	1,950	696.91	698.0	1,950	695.28	2,925	697.34
24	14,575	1,950	697.02	698.5	1,950	695.48	2,925	697.57
25	15,475	1,950	697.12	698.5	1,950	695.70	2,925	697.81
26	16,200	1,950	697.21	699.5	1,950	695.88	2,925	697.99
27	17,400	1,950	697.35	699.5	1,950	696.13	2,925	698.25
28	18,300	1,950	697.44	700.0	1,950	696.28	2,925	698.43
29	19,350	1,950	697.56	700.5	1,950	696.45	2,925	698.61
30	20,450	1,950	697.72	701.0	1,950	696.69	2,925	698.84
31	21,450	1,950	697.89	702.0	1,950	696.93	2,925	699.07

Table 4. Locust Creek water-surface elevations for the existing channel and alternative 3—a 70-foot excavated channel (cross sections 1–18)

[ft, feet; ft^3/s, cubic feet per second; --, no data]

Cross section (fig. 1)		Existing channel			70-ft excavated channel (cross sections 1–18)			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 5)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 5)	Discharge (ft^3/s)	Water-surface elevation (ft)
1	0	1,500	681.00	--	1,775	679.50	3,500	681.25
2	330	1,500	681.96	--	1,775	680.41	3,500	682.80
3	540	1,500	682.48	--	1,775	680.72	3,500	683.20
4	840	1,500	684.07	--	1,775	681.58	3,500	684.55
5	1,315	1,500	685.38	--	1,775	682.83	3,500	685.96
6X	1,565	1,500	685.76	--	1,775	683.38	3,500	686.46
7	2,015	1,500	686.47	--	1,775	684.20	3,500	687.08
8	2,475	1,500	687.39	--	1,775	685.16	3,500	687.90
9	2,910	1,500	688.12	--	1,775	686.20	3,500	689.07
10	3,250	1,500	688.72	--	1,775	686.80	3,500	689.70
11	3,875	1,500	691.19	--	1,775	687.90	3,500	690.85
12X	4,255	1,500	692.69	--	--	--	--	--
13	4,635	1,500	693.37	--	1,775	689.14	3,500	692.24
14	5,750	1,500	694.36	695.0	1,775	690.58	3,500	693.89
15	6,650	1,600	695.44	695.5	1,825	691.68	3,550	695.23
16X	7,025	1,650	695.94	--	--	--	--	--
17	7,400	1,750	696.10	696.0	1,900	692.32	3,650	695.89

Table 4. Locust Creek water-surface elevations for the existing channel and alternative 3—a 70-foot excavated channel (cross sections 1–18)—Continued

Cross section (fig. 1)		Existing channel			70-ft excavated channel (cross sections 1–18)			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 5)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 5)	Discharge (ft^3/s)	Water-surface elevation (ft)
18	8,400	1,900	696.34	696.5	1,950	692.82	3,750	696.35
19	9,420	1,950	696.54	696.5	1,950	693.25	3,800	696.81
20	10,450	1,950	696.65	697.0	1,950	693.51	3,800	697.17
21	11,415	1,950	696.72	697.5	1,950	693.68	3,800	697.41
22	12,425	1,950	696.80	698.0	1,950	693.88	3,800	697.69
23	13,525	1,950	696.91	698.0	1,950	694.14	3,800	698.03
24	14,575	1,950	697.02	698.5	1,950	694.44	3,800	698.36
25	15,475	1,950	697.12	698.5	1,950	694.78	3,800	698.67
26	16,200	1,950	697.21	699.5	1,950	695.04	3,800	698.89
27	17,400	1,950	697.35	699.5	1,950	695.39	3,800	699.23
28	18,300	1,950	697.44	700.0	1,950	695.59	3,800	699.47
29	19,350	1,950	697.56	700.5	1,950	695.80	3,800	699.68
30	20,450	1,950	697.72	701.0	1,950	696.13	3,800	699.96
31	21,450	1,950	697.89	702.0	1,950	696.44	3,800	700.22

Table 5. Locust Creek water-surface elevations for the existing channel and alternative 4—a 100-percent excavated channel (cross sections 1–18)

[ft, feet; ft^3/s, cubic feet per second; --, no data]

Cross section (fig. 1)		Existing channel			100-percent excavated channel (cross sections 1–18)			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 6)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 6)	Discharge (ft^3/s)	Water-surface elevation (ft)
1	0	1,500	681.00	--	1,850	679.00	5,200	683.25
2	330	1,500	681.96	--	1,850	679.92	5,200	684.57
3	540	1,500	682.48	--	1,850	680.14	5,200	684.85
4	840	1,500	684.07	--	1,850	681.03	5,200	685.60
5	1,315	1,500	685.38	--	1,850	682.42	5,200	686.99
6X	1,565	1,500	685.76	--	1,850	682.72	5,200	687.46
7	2,015	1,500	686.47	--	1,850	683.05	5,200	687.80
8	2,475	1,500	687.39	--	1,850	683.58	5,200	688.26
9	2,910	1,500	688.12	--	1,850	684.20	5,200	688.76
10	3,250	1,500	688.72	--	1,850	684.78	5,200	689.26
11	3,875	1,500	691.19	--	1,850	685.69	5,200	689.99
12X	4,255	1,500	692.69	--	--	--	--	--
13	4,635	1,500	693.37	--	1,850	686.78	5,200	691.04
14	5,750	1,500	694.36	695.0	1,850	688.28	5,200	692.63
15	6,650	1,600	695.44	695.5	1,875	689.27	5,250	693.92
16X	7,025	1,650	695.94	--	--	--	--	--
17	7,400	1,750	696.10	696.0	1,875	689.77	5,400	694.64

Table 5. Locust Creek water-surface elevations for the existing channel and alternative 4—a 100-percent excavated channel (cross sections 1–18)—Continued

Cross section (fig. 1)		Existing channel			100-percent excavated chennel (cross eections 1–18)			
Identifier	Stationing (ft)	Discharge (ft^3/s)	Water-surfece elevation (ft) (fig. 6)	Top of bank elevation (ft)	Discharge (ft^3/s)	Water-surface elevation (ft) (fig. 6)	Discharge (ft^3/s)	Water-surface elevation (ft)
18	8,400	1,900	696.34	696.5	1,950	690.17	5,450	695.19
19	9,420	1,950	696.54	696.5	1,950	690.64	5,450	695.76
20	10,450	1,950	696.65	697.0	1,950	691.14	5,450	696.43
21	11,415	1,950	696.72	697.5	1,950	691.41	5,450	696.86
22	12,425	1,950	696.80	698.0	1,950	691.70	5,450	697.32
23	13,525	1,950	696.91	698.0	1,950	692.09	5,450	697.87
24	14,575	1,950	697.02	698.5	1,950	692.65	5,450	698.39
25	15,475	1,950	697.12	698.5	1,950	693.39	5,450	698.89
26	16,200	1,950	697.21	699.5	1,950	693.83	5,450	699.23
27	17,400	1,950	697.35	699.5	1,950	694.27	5,450	699.70
28	18,300	1,950	697.44	700.0	1,950	694.48	5,450	699.97
29	19,350	1,950	697.56	700.5	1,950	694.72	5,450	700.22
30	20,450	1,950	697.72	701.0	1,950	695.22	5,450	700.59
31	21,450	1,950	697.89	702.0	1,950	695.72	5,450	701.00