FLOOD HYDRAULICS OF TECATE CREEK, TECATE, BAJA CALIFORNIA, MÉXICO

PROJECT NUMBER: W-04-09B

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NARRATIVE SUMMARY

A hydraulic study has been performed with the objective of ascertaining flood stages for an 11.56-km reach of Tecate Creek, in Tecate, Baja California, México. The study underpins ongoing studies to restore Tecate Creek to productive stability. The aim is to assure adequate flood conveyance for regulatory and design peak discharges, while preserving and enhancing related hydroecological, socioeconomic, and aesthetic functions.

The Hydrologic Engineering Center's River Analysis System model (HEC-RAS) has been used for this study (U.S. Army Corps of Engineers 2002). The peak discharges were developed in a companion study (Ponce et al., 2005). Two flood frequencies were considered: (1) a regulatory 10-year (yr) flood, and (2) a design 500-yr flood. It was found that the 10-yr flood would overflow the current low-flow channel in many of the existing cross sections. Moreover, the 500-yr flood would overflow the current high-flow channel in most of the existing cross sections.

Given the results of the hydraulic model, it is clear that an expanded flood control channel is needed for Tecate Creek. A prismatic 25-meter (m) width and 2.5-m depth low-flow channel would be able to convey the regulatory 10-yr flood. A 30-m width and 3.5-m depth high-flow flood plain would be able to convey the design 500-yr flood with an adequate freeboard. This channel would also be able to convey the maximum 10,000-yr flood by using the available freeboard. The proposed flood-plain channel underpins a long-term plan to provide much needed recreational space to enhance the quality of life of the local population.

The following conclusions are derived from this study:

- The 10-yr flood (268 m^3/sec) overflows the current low-flow channel in many of the existing cross sections (see cross sections of Figures 20-78).
- The 500-yr flood (997 m^3/sec) overflows the current high-flow channel in most of the existing cross sections (see cross sections of Figures 83-141).

- A 25-m width, 2.5-m depth, and size slope 2H:1V low-flow channel is able to convey the regulatory 10-yr flood.
- A 30-m width, 3.5-m depth, and size slope 2H:1V high-flow flood plain is able, when taken together with the low-flow channel, to convey the design 500-yr flood with an adequate freeboard (1.39 m).
- A 30-m width, 3.5-m depth, and size slope 2H:1V high-flow flood-plain channel is able to convey the maximum 10,000-yr flood by using most of the available freeboard.
- Right-of-way and related studies are required to guarantee that the entire reach of Tecate Creek (11.56 km) is in compliance with existing flood control regulations.
- The proposed 30-m wide flood-plain channel could be used to provide recreational space for the benefit of the local population.
- A long-term plan for a Tecate river park that reconciles hydrological, ecological, and economic objectives is envisioned.

FLOOD HYDRAULICS OF TECATE CREEK, TECATE, BAJA CALIFORNIA, MÉXICO

PROJECT NUMBER: W-04-09

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INTRODUCTION

Tecate Creek, in Tecate, Baja California, México (Figure 1), is being considered by local, state, and federal agencies for rehabilitation. The project encompasses 11.56 kilometers (km) of Tecate Creek, from the upstream end at Puente San José II, east of Tecate proper, to the downstream end at Puente La Puerta, west of Tecate (Figure 2). It is expected that the project will be executed in phases over the next twenty years, as resources become available.

The rehabilitation project seeks to provide a host of natural and anthropogenic functions to restore Tecate Creek to productive stability. Several functions will be enhanced by the rehabilitation project. These are: (1) flood conveyance, (2) groundwater replenishment, (3) compliance with federal stream-zoning regulations, (4) preservation of the riparian corridor, (5) enhancement of water quality, and (6) establishment of open areas for parks, sports and recreation, including landscaping and aesthetics.

The project is of strategic binational importance, since Tecate Creek forms part of the Tijuana river basin, which straddles the U.S.-Mexican border along the states of California and Baja California. The hydrologic system constituted by Campo-Tecate Creek has its headwaters near Live Oak Springs, in eastern San Diego County, California, and flows past the town of Campo, California into México. There, it changes name, first to Cañada Joe Bill, and then to Arroyo Tecate (Tecate Creek). Thus, the hydrologic fate of Tecate Creek and its contributing watershed is intertwined with that of Campo Creek, on the United States side of the border.

A companion study has determined flood discharges for return periods ranging from 2 years to 10,000 years (Ponce et al., 2005). The present study determines the hydraulics of the existing stream channel under a wide range of postulated flood discharges. Thus, this report focuses on the calculation of the water-surface profiles using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) (U.S. Army Corps of Engineers 2002). The use of this model is necessary to assess the existing stream channel's hydraulic competence to carry the regulatory and design floods. The 11.56-km study reach is currently in various stages of development. This includes: (a) reaches that have

been disturbed but are as yet undeveloped, (b) reaches that currently have plans for development, and (c) reaches where existing planned and/or unplanned development has encroached upon the stream's ability to convey the floods. On the basis of this analysis, several design choices would have to be made by the competent authorities, both federal and local, to guarantee a measure of flood protection to the population of Tecate.

BACKGROUND

The Comisión Nacional del Agua (CNA, National Water Commission of México), the Secretaría de Infraestructura y Desarrollo Urbano (SIDUE, Department of Infrastructure and Urban Development of Baja California), and the Ayuntamiento de Tecate (Municipality of Tecate) are the federal, state, and local government agencies, respectively, with jurisdiction over Tecate Creek. Previous studies have been performed by Rhoda Arkhos Ingeniería S.C. (Rhoda Arkhos undated), the California State Polytechnic University Studio 606 (2003), and the Centro de Estudios Sociales y Sustentables (2004). Other studies have been completed by Huffman & Carpenter, Inc. and the Institute of Regional Studies of the Californias (SDSU).

A comprehensive model-based flood hydrology study has been completed for Tecate Creek (Ponce et al. 2005). The specific tool is event rainfall-runoff modeling featuring distributed catchment parameterization. This includes distributed formulations of the following hydrologic processes: (a) precipitation, (b) hydrologic abstraction, (c) rainfall-runoff transform, (d) channel routing, and (e) channel transmission losses.

Based on the availability of depth-duration-frequency precipitation data, the catchment modeling (rainfall-runoff) was performed for 2-year (yr), 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr return periods. Once these values were established, extensions up to the 10,000-yr return period were developed using the Gumbel extreme-value probability distribution (Ponce 1989). In México and other countries, the 10,000-yr return period is used as a surrogate to the Probable Maximum Precipitation (PMP). Table 1 shows the complete series of flood peak discharges for Tecate Creek.

RESEARCH METHODOLOGY/APPROACHES

The HEC-RAS model calculates water-surface profiles when presented with the appropriate hydraulic and geometric data. The following data is required to run the model: (1) a set of digitized cross sections, (2) the friction coefficients for inbank and overbank flows, (3) the limits of inbank and overbank flows, (4) the lengths of inbank and overbank flows, (5) the design discharge, and (6) a suitable downstream boundary condition.

The cross sections are chosen to approximately represent the spatial variability of the stream channel. The limits of inbank and overbank flows are determined based on the field and laboratory examination of the cross-sectional geometry (Figure 3). The friction coefficients are estimated based on previous experience and established practice (Chow 1959; Barnes 1967). The design discharge is that corresponding to the chosen

return period (Table 1). The downstream boundary condition is usually taken as a calculated normal stage/depth based on a specified channel slope.

DATA COLLECTION

The total length of the modeled reach of Tecate Creek is 11,560 meters (m). To preserve accuracy, the distance between cross sections was chosen as 200 m. Accordingly, a total of 59 cross sections were obtained, based on the available topographic imagery. The topography and channel alignment are shown in Figures 4-6. For display purposes, in these figures, the total channel length is divided into three reaches: (a) downstream, (b) middle, and (c) upstream.

Table 2 shows the hydraulic and geometric characteristics of Tecate Creek. Column 1 shows sequential numbers for the cross sections. Column 2 shows the cumulative distance, measured from upstream to downstream, as needed for surveying purposes. Column 3 shows the relabeled station distances, from downstream to upstream, as needed for HEC-RAS modeling. Columns 4-6 show left overbank, center channel, and right overbank Manning friction coefficients, respectively. Columns 7 and 8 show left and right overbank station limits, respectively. Columns 9-11 show left overbank, center channel, and right overbank channel lengths, respectively.

Figure 7 shows the horizontal alignment of the upstream half reach. Figures 8-11 show details of the horizontal alignment for this reach. Figure 12 shows the geometric data for the horizontal alignment for this reach. Figure 13 shows the horizontal alignment of the downstream half reach. Figures 14-17 shows details of the horizontal alignment for this reach. Figure 18 shows the geometric data for the horizontal alignment for this reach.

Three levels of flood discharge are adopted for HEC-RAS modeling. The first level is used in Mexican practice to establish the limits of the regulatory or federal zone (the *Zona Federal*). This level is commonly taken as the 10-yr flood. The second level is used for flood control projects in mid-size cities such as Tecate. This level is established by CNA practice as the 500-yr flood. The third level is the frequency-based flood equivalent to the Probable Maximum Flood. This is the 10,000-yr flood, used to size the freeboard (Natural Resources Conservation Service 1960, Ponce 1989). Table 3 shows the design discharges adopted for this study: (1) regulatory, with 10-yr return period; (2) design, with 500-yr return period; and (3) probable maximum, with 10,000-yr return period. Lastly, the downstream boundary condition (S) was specified as a channel slope. This value was determined to be $S_o = 0.00692$.

RESEARCH FINDINGS

The results of the HEC-RAS simulation using the existing cross sections are shown in Figures 19-144. Figures 19-81 show the results for the 10-yr frequency, and Figures 82-144 show the results for the 500-yr frequency.

Figure 19 shows the water-surface profile for the peak discharge corresponding to the 10-yr frequency. Figures 20-78 show the 59 calculated cross sections, from 11+560 to 0+000, every 200 m. Figures 79 and 80 show the calculated channel velocities and

Froude numbers, respectively. Figure 81 shows the HEC-RAS summary table, including the water-surface elevations for all the cross sections.

Figure 82 shows the water-surface profile for the peak discharge corresponding to the 500-yr frequency. Figure 83-141 show the 59 calculated cross sections, from 11+560 to 0+000, every 200 m. Figures 142 and 143 show the calculated channel velocities and Froude numbers, respectively. Figure 144 shows the HEC-RAS summary table, including the water-surface elevations for all the cross sections.

A second series of HEC-RAS runs was accomplished by designing a prismatic six-point flood channel to convey the 10-yr flood inbank and the 500-yr flood out-of-bank, including an engineered flood plain. The design cross section was dimensioned to convey the 500-yr flood with a suitable freeboard. Accordingly, the inbank channel was set at 25-m width and 2.5-m depth, with side slope 2:1 (H:V). The flood plain (out-of-bank channel) was set at 30-m width and 3.5-m depth, with side slopes 2:1 (H:V).

Figure 145 shows the water-surface profile for the peak discharge corresponding to the 10-yr, 500-yr, and 10,000-yr frequencies. Figures 146 and 147 show two typical cross sections: (1) upstream, at 11+560 m, and (2) downstream, at 0+000 m. Figure 148 shows the HEC-RAS summary table, including the water-surface elevations for all seven cross sections.

Figure 148 shows that the freeboard in the inbank channel (10-yr frequency) is: 474.50 - 474.39 = 0.11 m. Likewise, the freeboard for the floodplain channel for the 500-yr frequency is: 478.00- 476.61 = 1.39 m. Also, the freeboard for the flood-plain channel for the probable maximum flood (10,000-yr) is: 478.00- 477.65 = 0.35 m. Channel velocities are 3.77, 5.74, and 6.50 m/s for the 10-yr, 500-yr, and 10,000-yr floods, respectively. Froude numbers are 0.84, 0.93, and 0.95, respectively. The results are summarized in Table 4.

CONCLUSIONS

A hydraulic assessment has been made of the ability of the present Tecate Creek to convey regulatory (10-yr) and design (500-yr) flood discharges. It is shown that the current flood channel is limited in some cross sections in its ability to convey the 10-yr and 500-yr floods. An expanded cross section is suggested, together with a vision for a flood-plain channel that can readily double as recreational space.

The following conclusions are derived from this study:

- The 10-yr flood (268 m^3/sec) overflows the current low-flow channel in many of the existing cross sections (see cross sections of Figures 20-78).
- The 500-yr flood (997 m^3/sec) overflows the current high-flow channel in most of the existing cross sections (see cross sections of Figures 83-141).
- A 25-m width, 2.5-m depth, and size slopes 2H:1V low-flow channel is able to convey the regulatory 10-yr flood.

- A 30-m width, 3.5-m depth, and size slopes 2H:1V high-flow flood plain is able, when taken together with the low-flow channel, to convey the design 500-yr flood with an adequate freeboard (1.39 m).
- A 30-m width, 3.5-m depth, and size slopes 2H:1V high-flow flood-plain channel is able to convey the maximum 10,000-yr flood by using most of the available freeboard.
- Right-of-way and related studies are required to guarantee that the entire reach of Tecate Creek (11.56 km) is in compliance with existing flood control regulations.
- The proposed 30-m wide flood-plain channel could be used to provide recreational space for the benefit of the local population.
- A long-term plan for a Tecate river park that reconciles hydrological, ecological, and economic objectives is envisioned.

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APPENDIX

Table 1. Flood peak discharges for Tecate Creek	
Return period (yr)	Flood peak discharge (m^3/s)
2	87
5	190
10	268
25	396
50	675
100	770
200	843
500	997
1000	1,113
2,000	1,230
5,000	1,383
10,000	1,499

Table 2. Cross-section hydraulic and geometric characteristics for HEC-RAS model[1]										
No.	Distance from u/s (m)	HEC-RAS station (m)	L. O. n	C. Ch. n	R. O. n	L. O. limit (m)	R. O. limit (m)	L. O. length (m)	Channel length (m)	R. O. length (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	0+000	11+560	0.055	0.030	0.055	2.607	28.0871	188.137	200.000	211.863
2	0+200	11+360	0.065	0.035	0.050	53.764	124.326	217.602	200.000	182.398
3	0+400	11+160	0.050	0.030	0.070	19.022	67.456	266.274	200.000	133.726
4	0+600	10+960	0.070	0.035	0.060	166.924	226.002	176.349	200.000	221.998
5	0+800	10+760	0.070	0.035	0.050	87.55	115.806	200.000	200.000	200.000
6	1+000	10+560	0.070	0.035	0.050	5.94	78.873	219.815	200.000	179.794
7	1+200	10+360	0.050	0.030	0.060	43.767	106.121	196.989	200.000	203.009
8	1+400	10+160	0.070	0.040	0.060	44.552	119.128	230.232	200.000	169.768
9	1+600	9+960	0.050	0.035	0.060	50.905	194.257	214.160	200.000	185.840
10	1+800	9+760	0.050	0.035	0.070	7.561	99.223	173.018	200.000	226.982
11	2+000	9+560	0.050	0.030	0.060	12.510	181.616	200.000	200.000	200.000
12	2+200	9+360	0.050	0.030	0.060	110.179	301.564	184.419	200.000	215.581
13	2+400	9+160	0.060	0.035	0.070	253.533	382.722	216.138	200.000	183.862
14	2+600	8+960	0.050	0.035	0.050	157.525	219.931	211.267	200.000	188.733
15	2+800	8+760	0.070	0.035	0.060	198.68	300.81	202.953	200.000	197.047
16	3+000	8+560	0.070	0.050	0.070	45.447	127.35	200.000	200.000	200.000
17	3+200	8+360	0.050	0.030	0.070	30.325	166.778	219.561	200.000	180.066
18	3+400	8+160	0.050	0.030	0.070	9.461	86.307	200.000	200.000	200.000
19	3+600	7+960	0.050	0.030	0.050	79.077	134.986	171.760	200.000	230.516
20	3+800	7+760	0.050	0.035	0.050	95.231	192.080	214.988	200.000	185.012
21	4+000	7+560	0.050	0.030	0.050	71.057	144.537	200.000	200.000	200.000
22	4+200	7+360	0.050	0.030	0.050	109.224	180.096	230.531	200.000	169.470
23	4+400	7+160	0.070	0.035	0.060	162.003	189.080	175.330	200.000	224.670
24	4+600	6+960	0.050	0.030	0.050	361.058	386.521	163.821	200.000	236.180
25	4+800	6+760	0.055	0.035	0.055	116.874	142.036	193.663	200.000	206.337

26	5+000	6+560	0.070	0.040	0.060	193.097	217.756	197.175	200.000	202.825
27	5+200	6+360	0.050	0.045	0.050	300.665	336.592	172.943	200.000	227.057
28	5+400	6+160	0.065	0.050	0.060	259.310	281.740	206.455	200.000	193.545
29	5+600	5+960	0.060	0.045	0.06	214.170	237.200	206.927	200.000	193.073
30	5+800	5+760	0.060	0.040	0.060	162.210	193.060	228.103	200.000	171.897
31	6+000	5+560	0.050	0.030	0.060	79.800	108.100	181.311	200.000	218.689
32	6+200	5+360	0.050	0.035	0.065	321.260	347.500	175.000	200.000	225.000
33	6+400	5+160	0.075	0.050	0.075	319.050	346.000	193.432	200.000	206.568
34	6+600	4+960	0.090	0.070	0.090	334.500	354.400	225.792	200.000	174.208
35	6+800	4+760	0.090	0.070	0.080	214.100	242.400	200.000	200.000	200.000
36	7+000	4+560	0.050	0.050	0.070	110.700	154.200	239.257	200.000	165.657
37	7+200	4+360	0.070	0.050	0.070	40.107	97.658	165.676	200.000	234.335
38	7+400	4+160	0.050	0.035	0.050	91.900	112.141	171.208	200.000	228.792
39	7+600	3+960	0.070	0.055	0.065	141.600	200.500	159.216	200.000	240.784
40	7+800	3+760	0.070	0.040	0.070	162.500	211.600	275.354	200.000	134.774
41	8+000	3+560	0.070	0.050	0.070	146.500	201.300	111.113	200.000	288.887
42	8+200	3+360	0.070	0.035	0.070	161.700	225.000	218.780	200.000	181.703
43	8+400	3+160	0.070	0.035	0.070	30.800	111.300	200.000	200.000	200.000
44	8+600	2+960	0.090	0.070	0.090	93.900	194.600	200.000	200.000	200.000
45	8+800	2+760	0.080	0.040	0.070	73.200	261.600	256.107	200.000	143.893
46	9+000	2+560	0.070	0.040	0.070	56.404	143.345	164.710	200.000	235.290
47	9+200	2+360	0.070	0.035	0.060	220.400	301.800	236.660	200.000	163.340
48	9+400	2+160	0.070	0.040	0.070	39.300	85.600	202.127	200.000	197.872
49	9+600	1+960	0.070	0.035	0.080	50.500	169.500	225.485	200.000	174.515
50	9+800	1+760	0.070	0.040	0.080	85.700	170.100	209.202	200.000	190.614
51	10+000	1+560	0.090	0.050	0.090	161.900	199.629	169.232	200.000	230.768
52	10+200	1+360	0.070	0.035	0.070	133.776	168.146	185.556	200.000	214.444
53	10+400	1+160	0.070	0.035	0.070	93.933	160.866	219.768	200.000	180.232
54	10+600	0+960	0.060	0.035	0.060	4.731	142.056	229.139	200.000	170.861

55	10+800	0+760	0.060	0.035	0.060	79.252	187.027	168.413	200.000	229.121
56	11+000	0+560	0.060	0.035	0.060	96.192	175.461	171.274	200.000	228.726
57	11+200	0+360	0.060	0.035	0.060	26.364	142.680	257.403	200.000	142.597
58	11+400	0+160	0.060	0.035	0.060	28.674	172.544	132.376	160.000	188.749
59	11+560	0+000	0.060	0.035	0.060	58.666	132.860	0.000	0.000	0.000

[1] L. O. = left overbank; n = Manning n; C. Ch. = center channel, R. O. = right overbank

Table 3. Design flood peak discharges for Tecate Creek			
Level	Level of protection	Return period (yr)	Flood peak discharge (m^3/s)
1	Regulatory	10	268
2	Design	500	997
3	Maximum	10,000	1,499

Table 4. Hydraulic characteristics of flood-conveyance channel for Tecate Creek

Level	Level of protection	Return period (yr)	Flood peak discharge (m^3/s)	Channel depth (m)	Channel velocity (m/s)	Froude number	Freeboard (m)
1	Regulatory	10	268	2.39	3.77	0.84	0.11 [1]
2	Design	500	997	4.61	5.74	0.93	1.39 [2]
3	Maximum	10,000	1,499	5.65	6.50	0.95	0.35 [2]

[1] inbank channel. [2] flood-plain channel

Figure 1. Tecate Creek, downstream of Tecate, Baja California

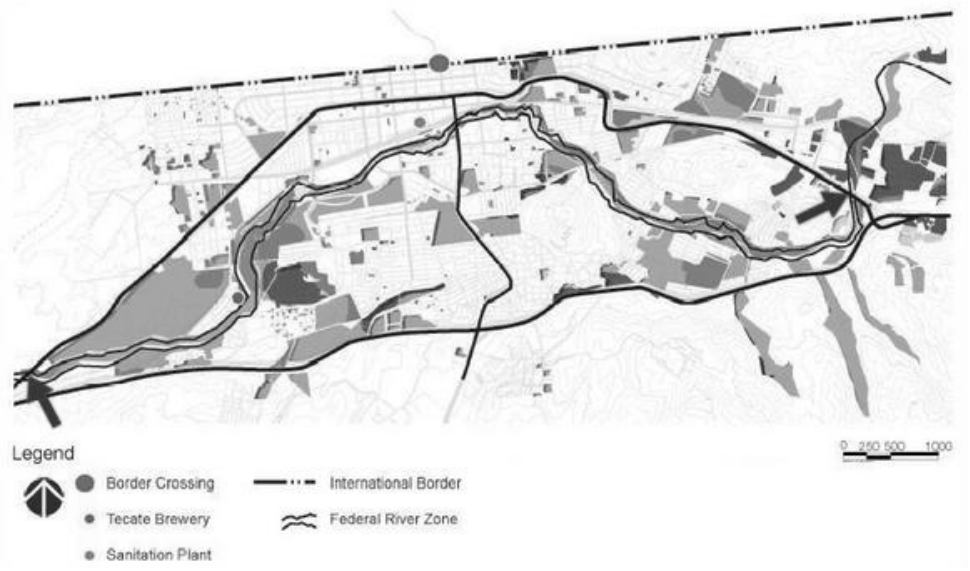

Figure 2. Tecate Creek project limits: Puente San Jose II (east), and Puente La Puerta (west) (Source: Huffman & Carpenter, Inc.)

Figure 3. Upstream view of Tecate Creek at El Descanso

Figure 4. Detail of the topography and horizontal alignment: downstream third

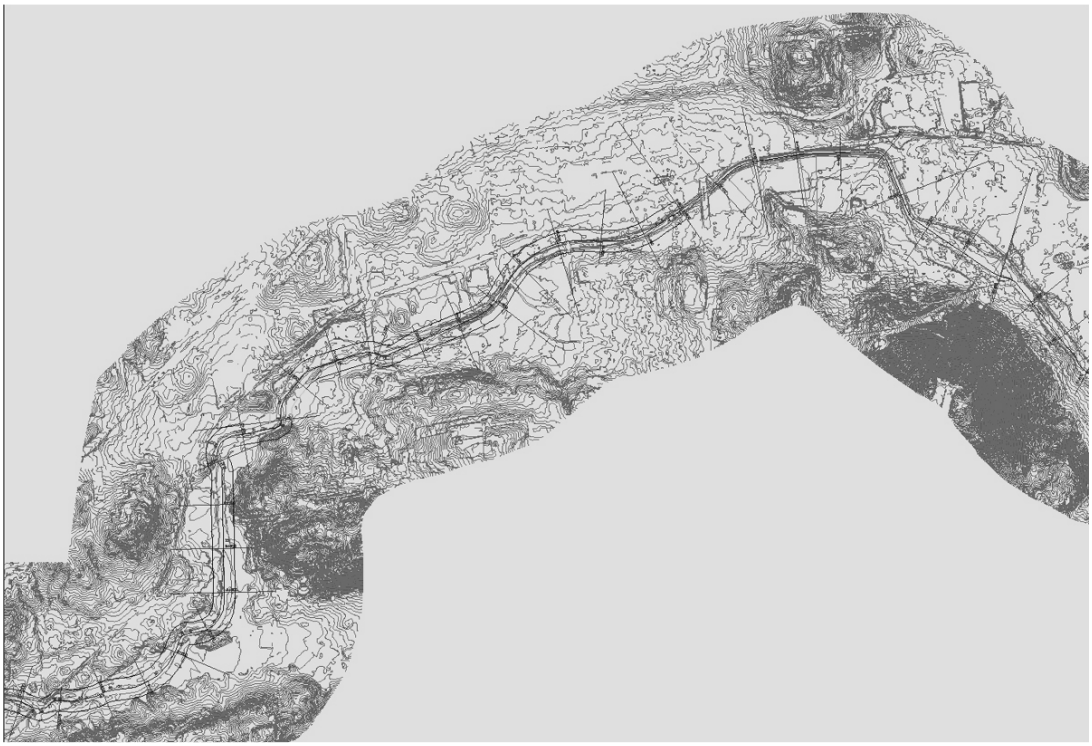

Figure 5. Detail of the topography and horizontal alignment: middle third

Figure 6. Detail of the topography and horizontal alignment: upstream third

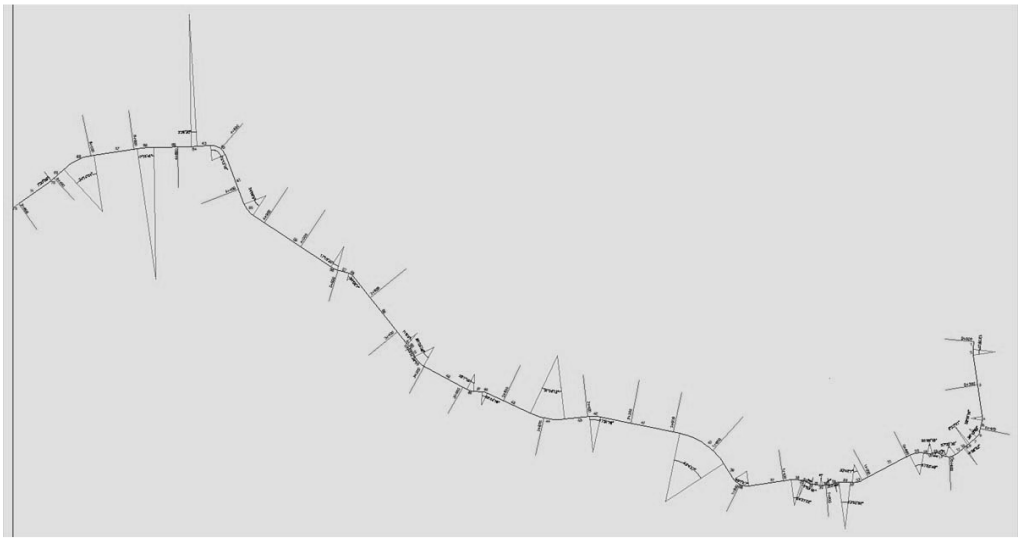

Figure 7. Horizontal alignment of the upstream half reach

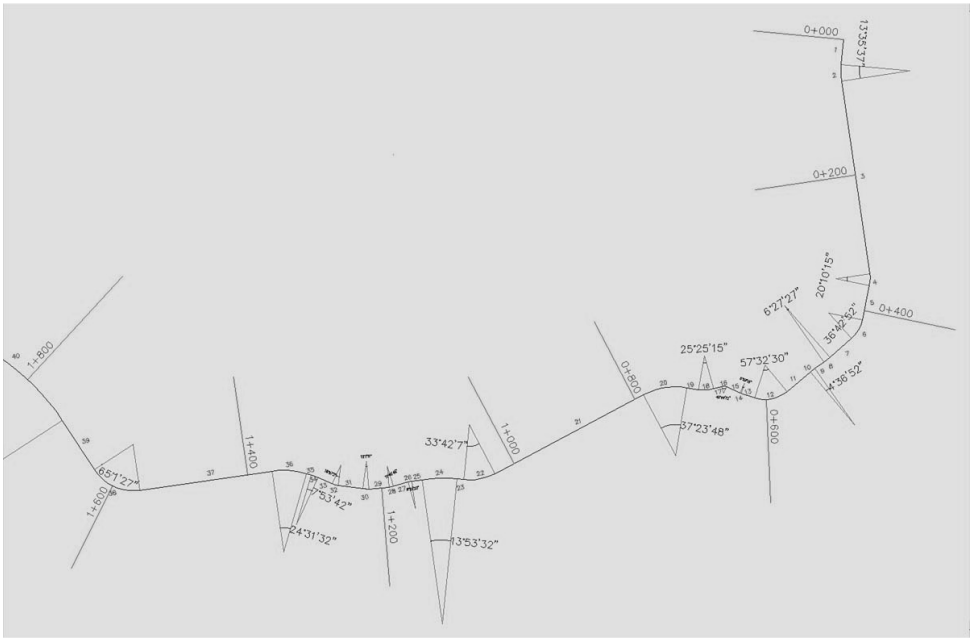

Figure 8. Detail of the horizontal alignment of the upstream half reach (1)

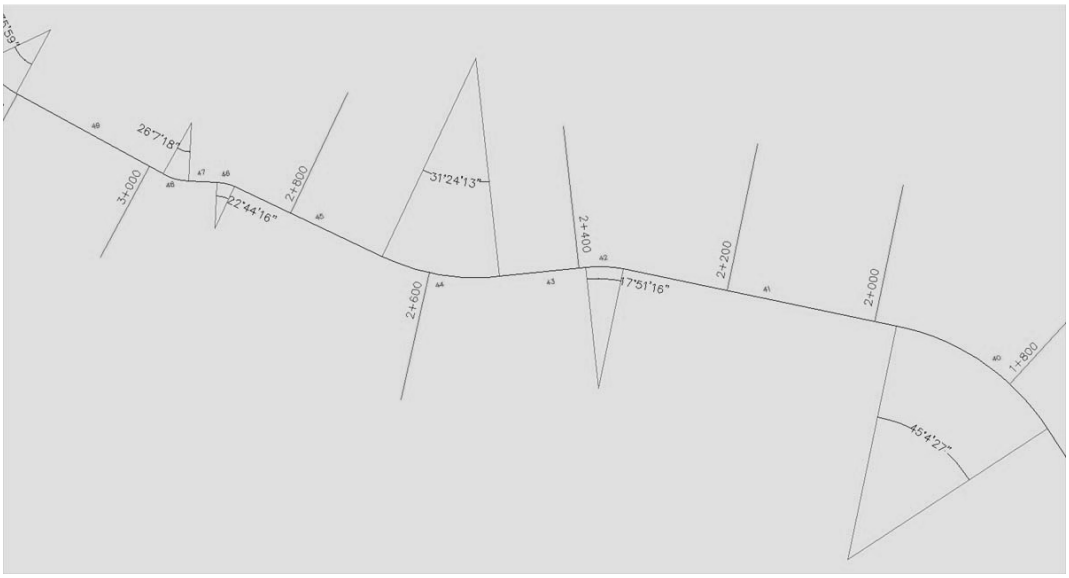

Figure 9. Detail of the horizontal alignment of the upstream half reach (2)

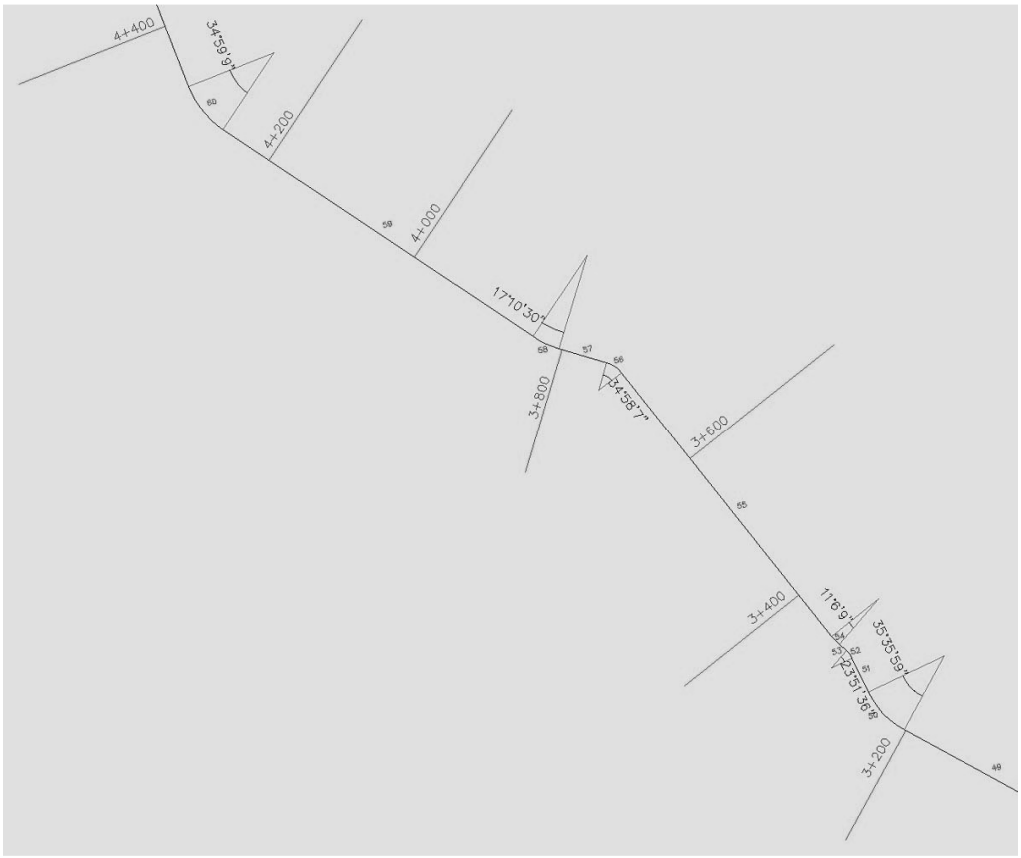

Figure 10. Detail of the horizontal alignment of the upstream half reach (3)

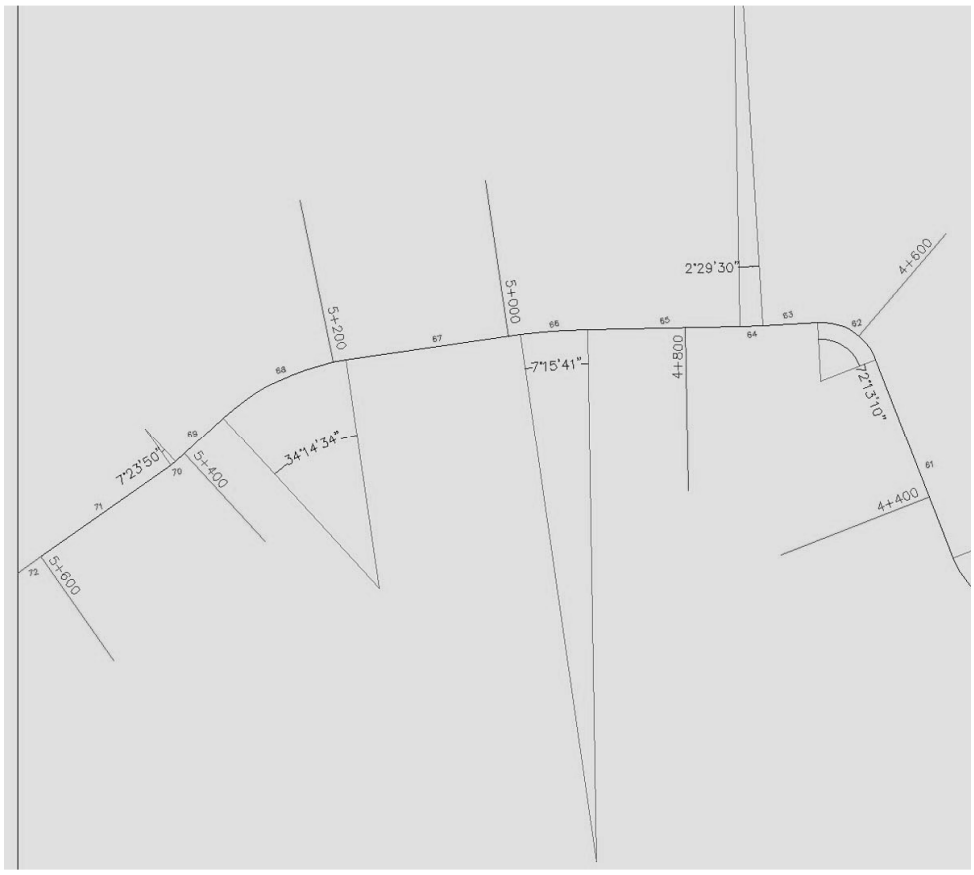

Figure 11. Detail of the horizontal alignment of the upstream half reach (4)

Upstream Reach				
No.	Type	Length (m)	Radius (m)	Angle
1	Tangent	37.203		
2	Curve	23.726	100.000	13°35'37"
3	Tangent	283.862		
4	Curve	17.602	50.000	20°10'15"
5	Tangent	50.908		
6	Curve	32.039	50.000	36°42'52"
7	Tangent	41.348		
8	Curve	11.270	100.000	6°27'27"
9	Tangent	16.425		
10	Curve	8.054	100.000	4°36'52"
11	Tangent	44.938		
12	Curve	50.214	50.000	57°32'30"
13	Tangent	20.309		
14	Curve	1.803	15.000	6°53'19"
15	Tangent	21.814		
16	Curve	7.110	10.000	40°44'12"
17	Tangent	12.424		
18	Curve	22.184	50.000	25°25'15"
19	Tangent	17.487		
20	Curve	65.269	100.000	37°23'48"
21	Tangent	245.482		
22	Curve	47.057	80.000	33°42'07"
23	Tangent	9.575		
24	Curve	51.322	211.669	13°53'32"
25	Tangent	15.098		
26	Curve	5.880	40.000	8°25'23"
27	Tangent	22.507		
28	Curve	6.159	30.000	11°45'45"
29	Tangent	29.734		
30	Curve	8.391	40.000	12°01'11"
31	Tangent	36.320		
32	Curve	8.876	30.000	16°57'03"
33	Tangent	23.214		
34	Curve	10.334	75.000	7°53'42"
35	Tangent	7.414		
36	Curve	50.988	119.117	24°31'32"
37	Tangent	194.963		
38	Curve	76.385	67.306	65°01'27"
39	Tangent	86.233		
40	Curve	248.630	316.044	45°04'27"
41	Tangent	370.038		
42	Curve	50.347	161.566	17°51'16"
43	Tangent	115.261		
44	Curve	159.293	290.630	31°24'13"
45	Tangent	216.953		
46	Curve	24.033	60.560	22°44'16"
47	Tangent	37.833		
48	Curve	35.199	77.206	26°07'18"
49	Tangent	222.762		
50	Curve	59.729	96.131	35°35'59"
51	Tangent	43.395		
52	Curve	10.850	26.056	23°51'36"
53	Tangent	10.355		
54	Curve	13.355	68.917	11°06'09"
55	Tangent	386.277		
56	Curve	20.050	32.852	34°58'07"
57	Tangent	57.051		
58	Curve	33.251	110.924	17°10'30"
59	Tangent	426.248		
60	Curve	63.915	104.673	34°59'09"
61	Tangent	240.549		
62	Curve	83.551	66.285	72°13'10"
63	Tangent	61.648		
64	Curve	26.093	600.000	2°29'30"
65	Tangent	171.974		
66	Curve	76.041	600.000	7°15'41"
67	Tangent	198.686		
68	Curve	155.601	260.356	34°14'34"
69	Tangent	72.732		
70	Curve	6.455	50.000	7°23'50"
71	Tangent	179.923		
72	Tangent	31.644		
Total		5631.643		

Figure 12. Geometric data for the horizontal alignment of the upstream half reach

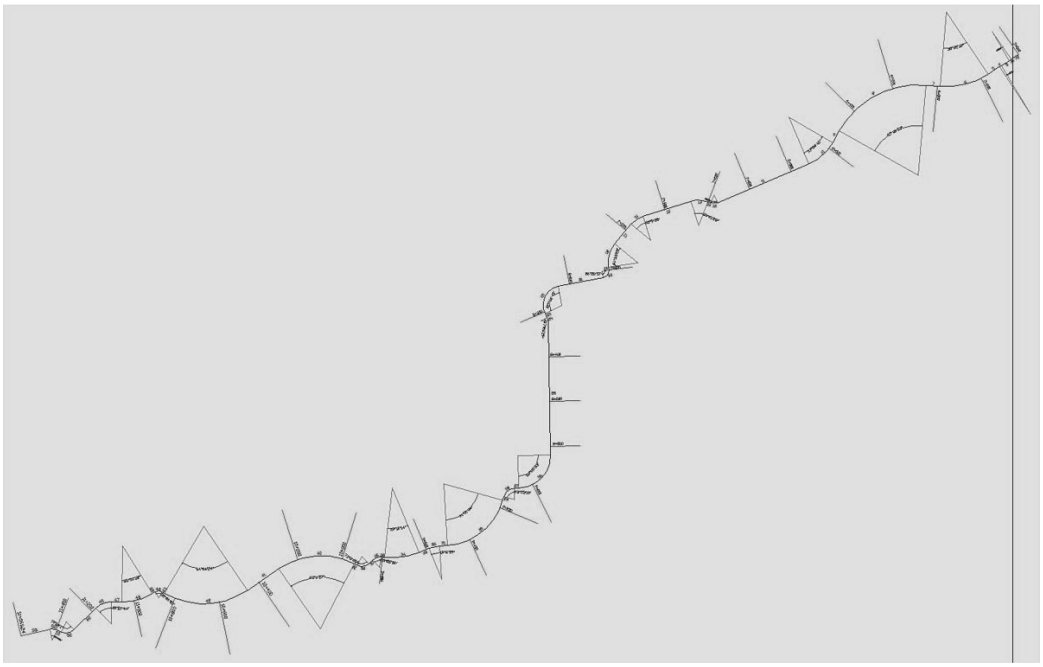

Figure 13. Horizontal alignment of the downstream reach, from right to left, 5+600 to 11+560 m (more detail in next figure)

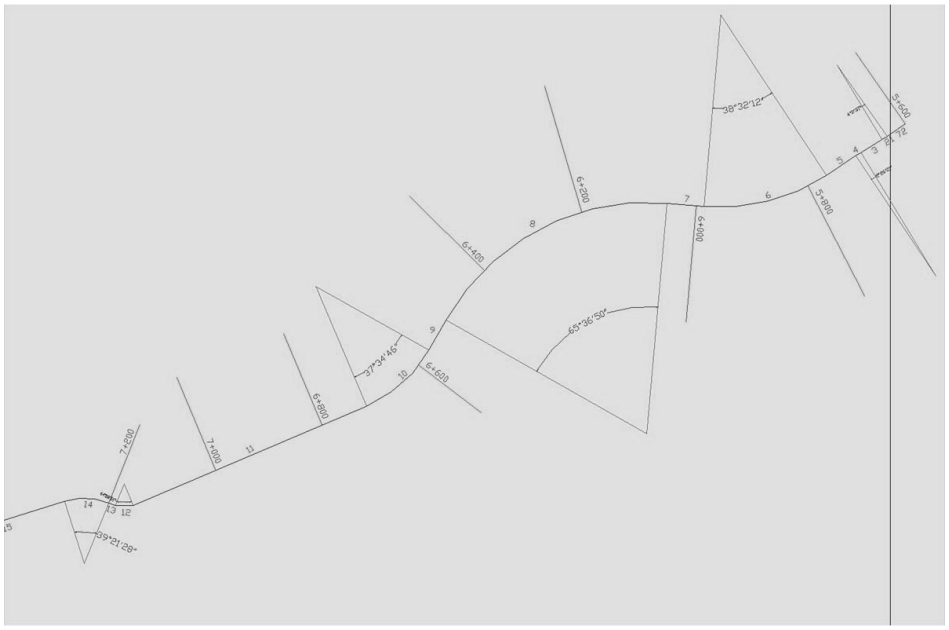

Figure 14. Detail of the horizontal alignment of the downstream half reach (1)

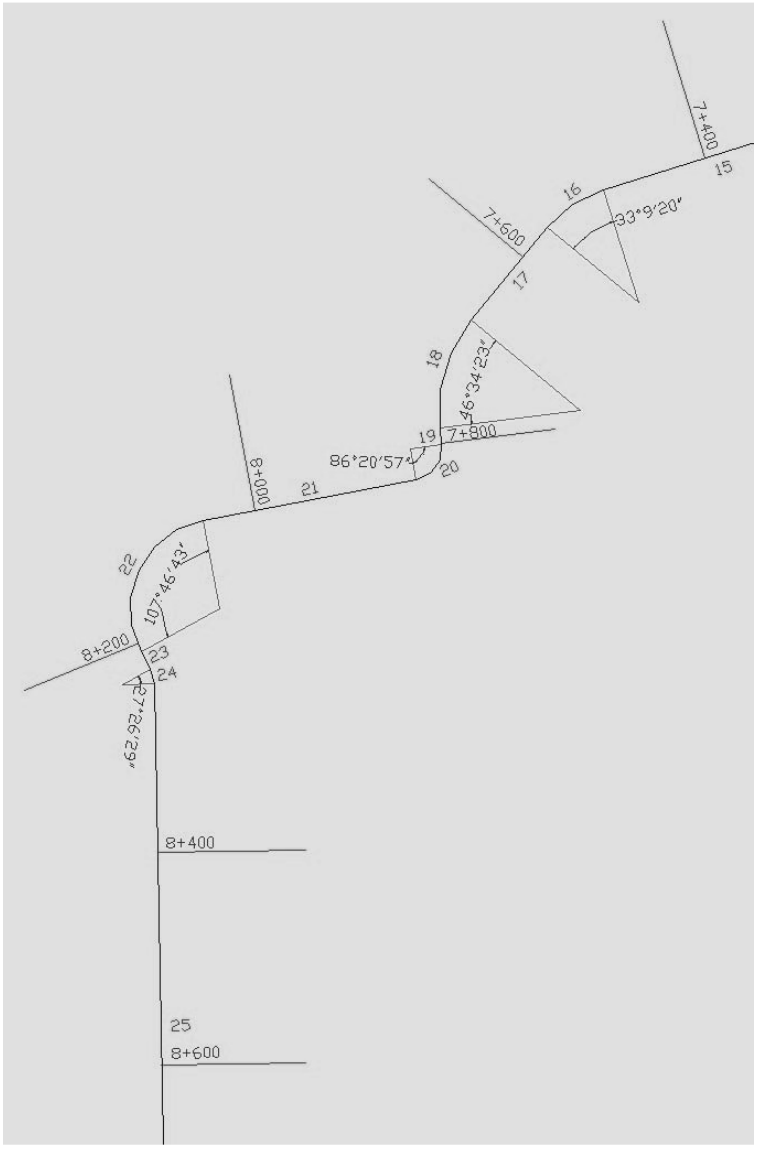

Figure 15. Detail of the horizontal alignment of the downstream half reach (2)

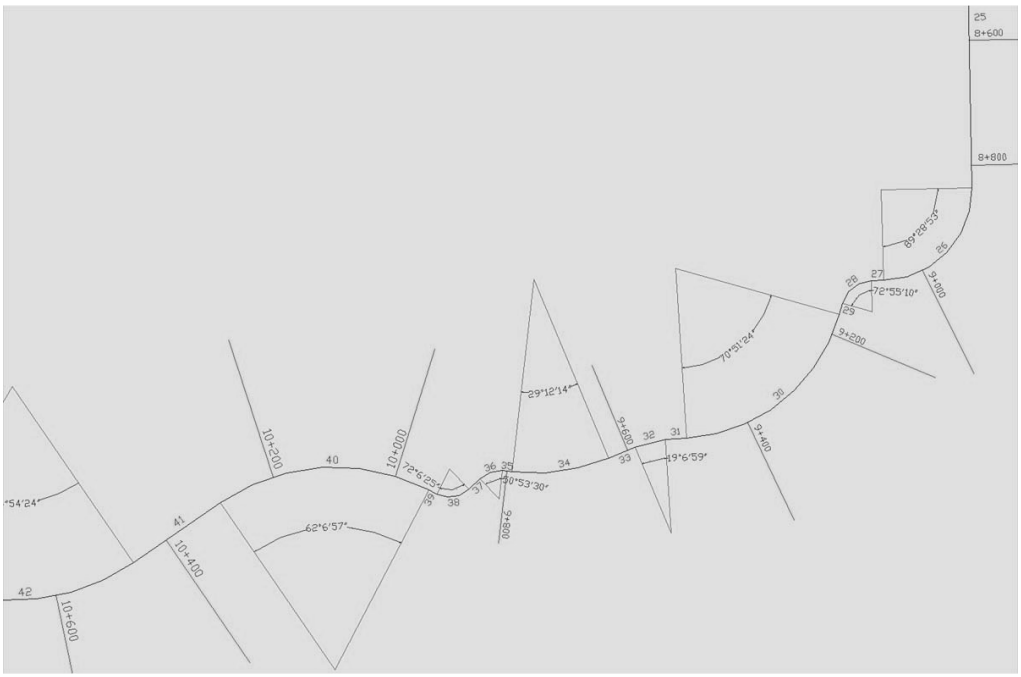

Figure 16. Detail of the horizontal alignment of the downstream half reach (3)

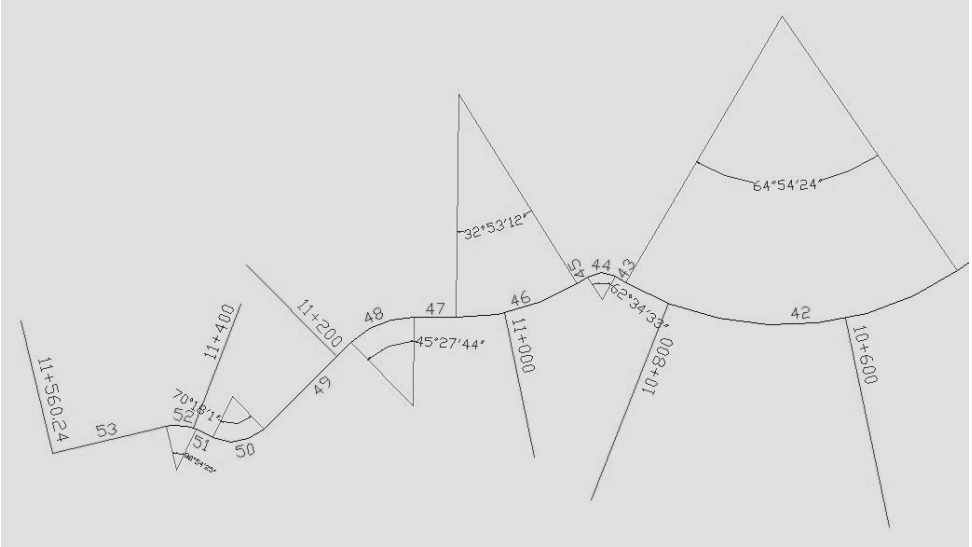

Figure 17. Detail of the horizontal alignment of the downstream half reach (4)

Downstream Reach				
No.	Type	Length (m)	Radius (m)	Angle
1	Tangent	6.802		
2	Curve	10.586	150.000	4°02'37"
3	Tangent	42.347		
4	Curve	10.643	250.000	2°26'21"
5	Tangent	61.278		
6	Curve	223.301	332.000	38°32'12"
7	Tangent	63.889		
8	Curve	458.071	400.000	65°36'50"
9	Tangent	59.940		
10	Curve	147.521	224.920	37°34'46"
11	Tangent	439.973		
12	Curve	31.414	40.000	44°59'51"
13	Tangent	12.564		
14	Curve	77.610	112.982	39°21'28"
15	Tangent	222.466		
16	Curve	64.227	110.989	33°09'20"
17	Tangent	113.120		
18	Curve	108.330	133.272	46°34'23"
19	Tangent	15.544		
20	Curve	45.212	30.000	86°20'57"
21	Tangent	203.191		
22	Curve	159.066	84.560	107°46'43"
23	Tangent	18.673		
24	Curve	14.368	30.000	27°26'29"
25	Tangent	595.091		
26	Curve	227.033	145.371	89°28'53"
27	Tangent	20.164		
28	Curve	63.634	50.000	72°55'10"
29	Tangent	17.577		
30	Curve	337.335	272.774	70°51'24"
31	Tangent	34.506		
32	Curve	50.046	150.000	19°06'59"
33	Tangent	45.741		
34	Curve	158.274	310.522	29°12'14"
35	Tangent	15.796		
36	Curve	39.970	45.000	50°53'30"
37	Tangent	24.278		
38	Curve	56.633	45.000	72°06'25"
39	Tangent	13.672		
40	Curve	352.358	325.015	62°06'57"
41	Tangent	170.430		
42	Curve	388.775	343.188	64°54'24"
43	Tangent	12.963		
44	Curve	32.765	30.000	62°34'33"
45	Tangent	13.078		
46	Curve	142.433	248.149	32°53'12"
47	Tangent	46.511		
48	Curve	77.840	98.102	45°27'44"
49	Tangent	135.733		
50	Curve	61.349	50.000	70°18'01"
51	Tangent	20.288		
52	Curve	33.953	50.000	38°54'25"
53	Tangent	130.233		
Total		5928.595		

Figure 18. Geometric data for the horizontal alignment of the downstream half reach

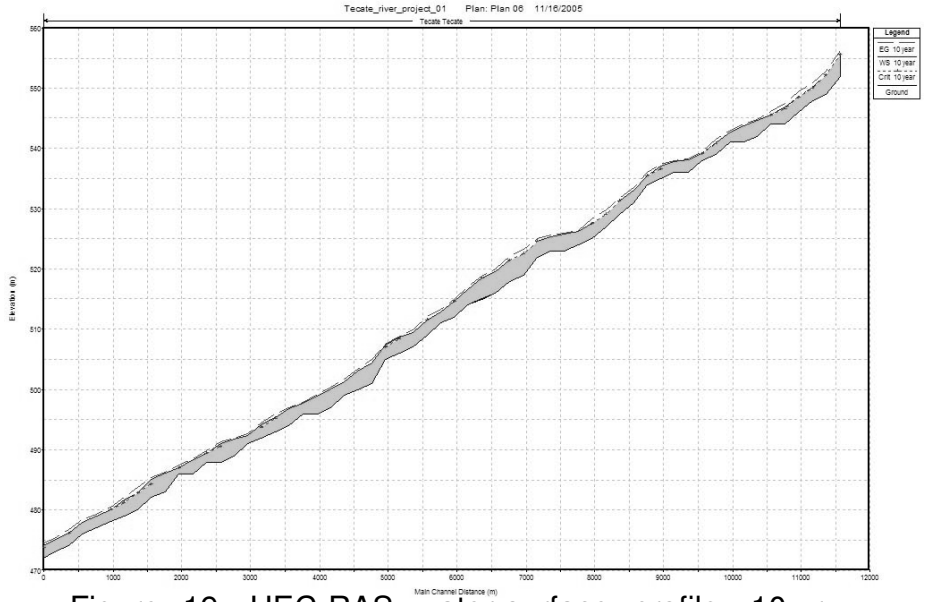

Figure 19. HEC-RAS water-surface profile, 10-yr frequency

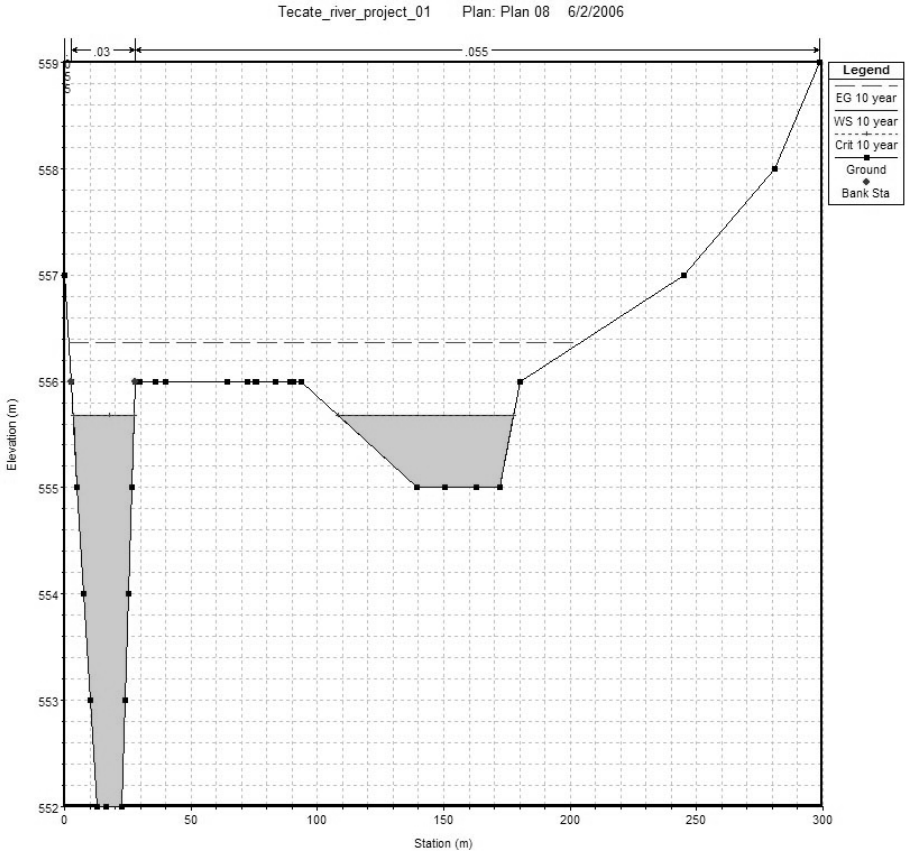

Figure 20. Calculated cross section at RM 11+560, 10-yr frequency

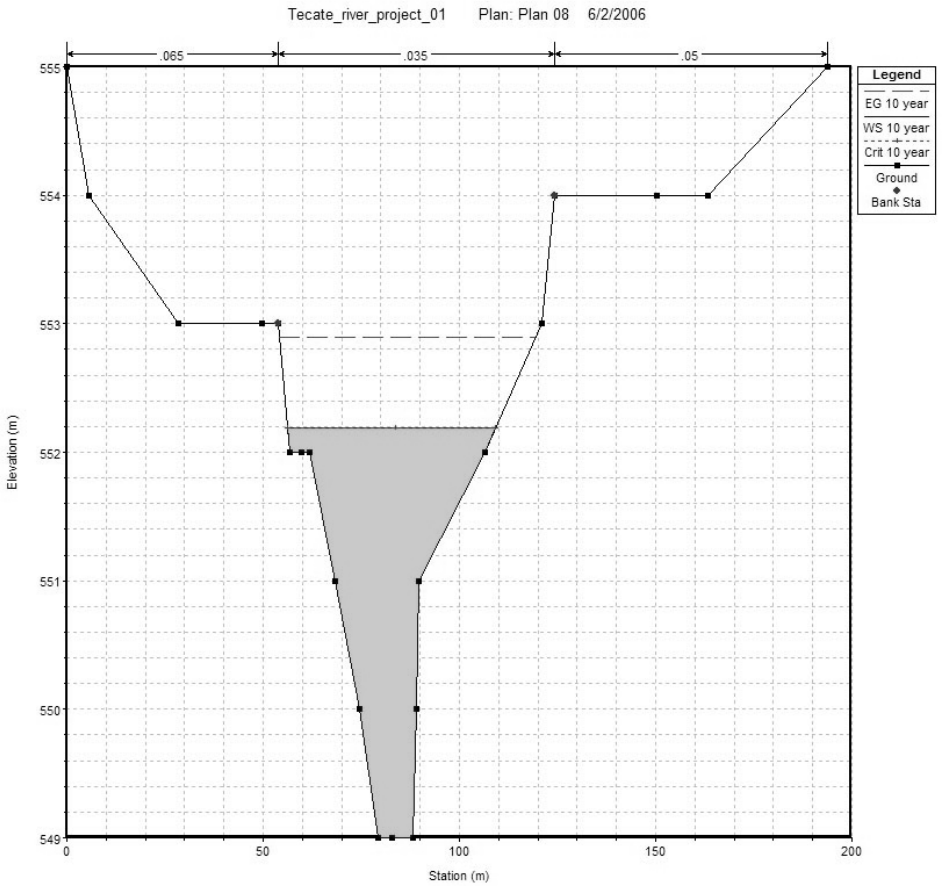

Figure 21. Calculated cross section at RM 11+360, 10-yr frequency

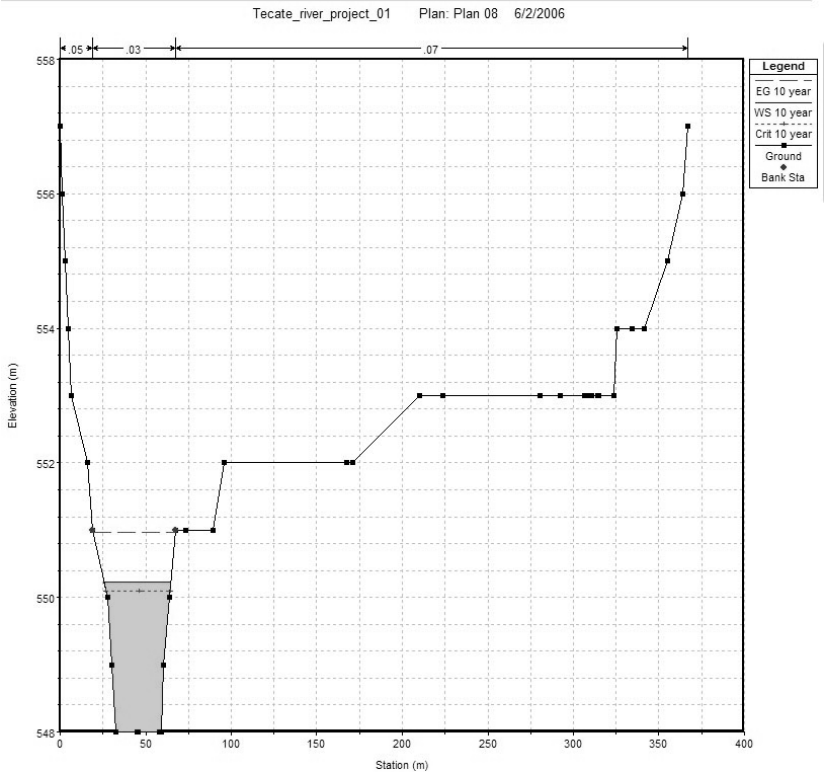

Figure 22. Calculated cross section at RM 11+160, 10-yr frequency

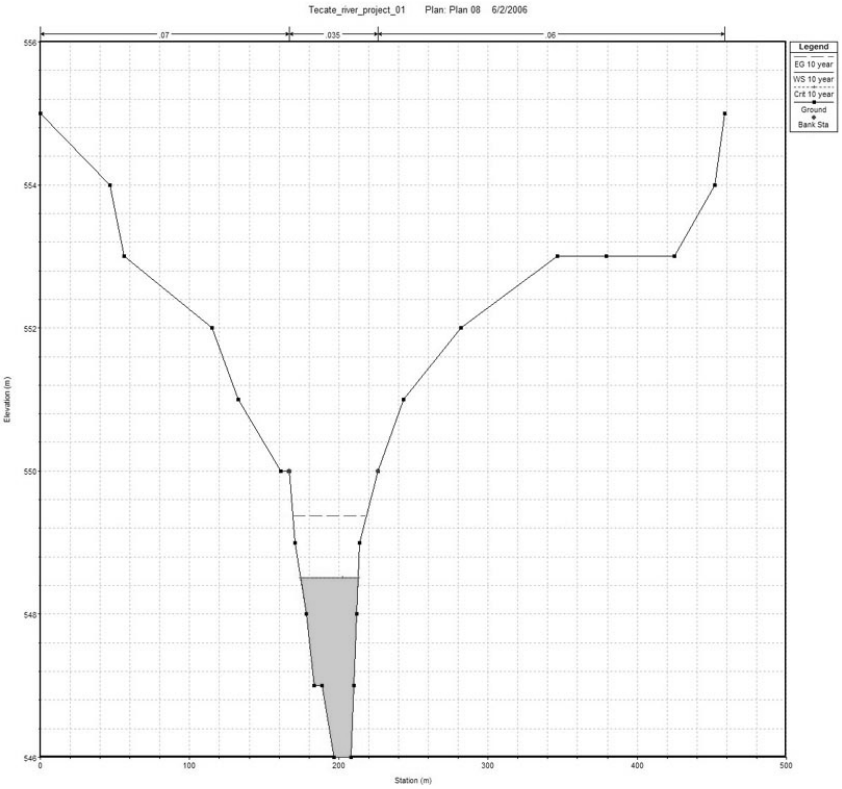

Figure 23. Calculated cross section at RM 10+960, 10-yr frequency.

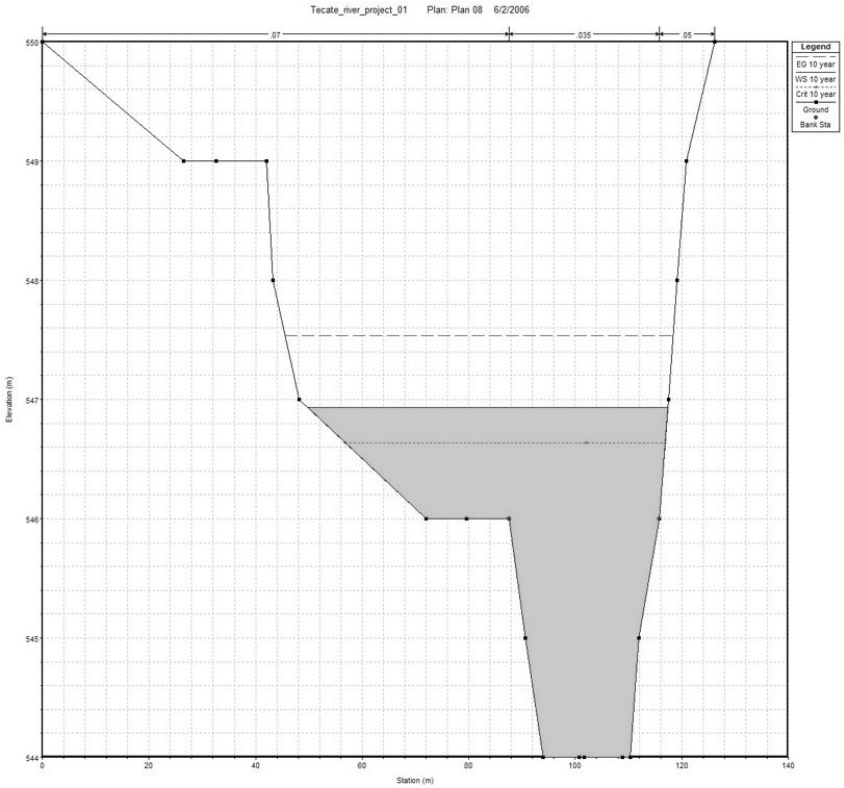

Figure 24. Calculated cross section at RM 10+760, 10-yr frequency

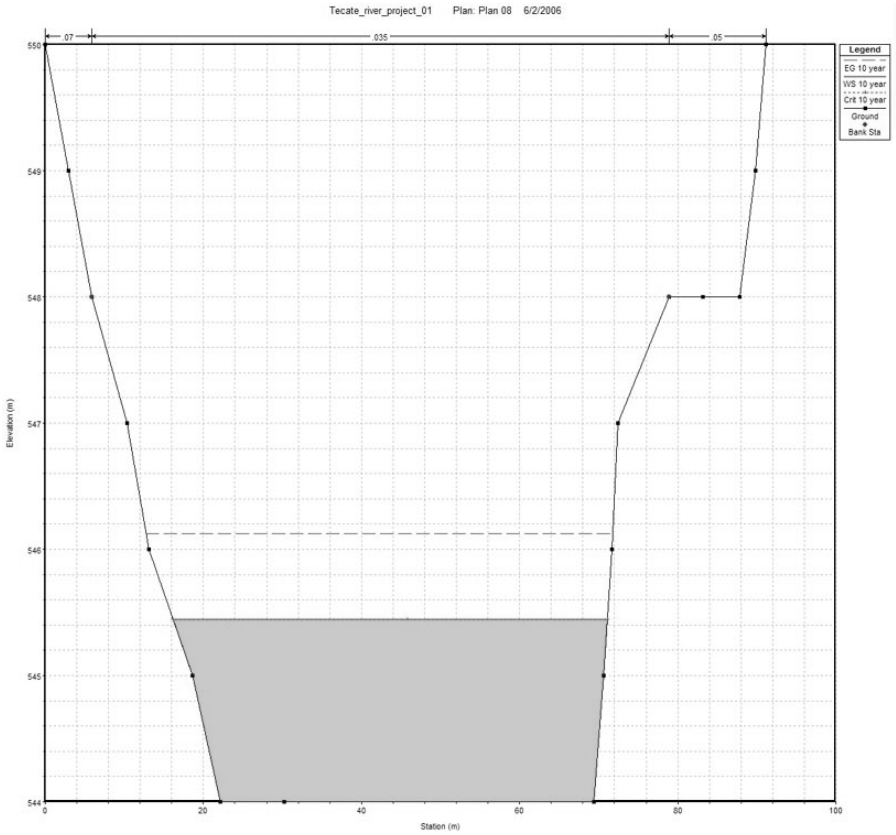

Figure 25. Calculated cross section at RM 10+560, 10-yr frequency

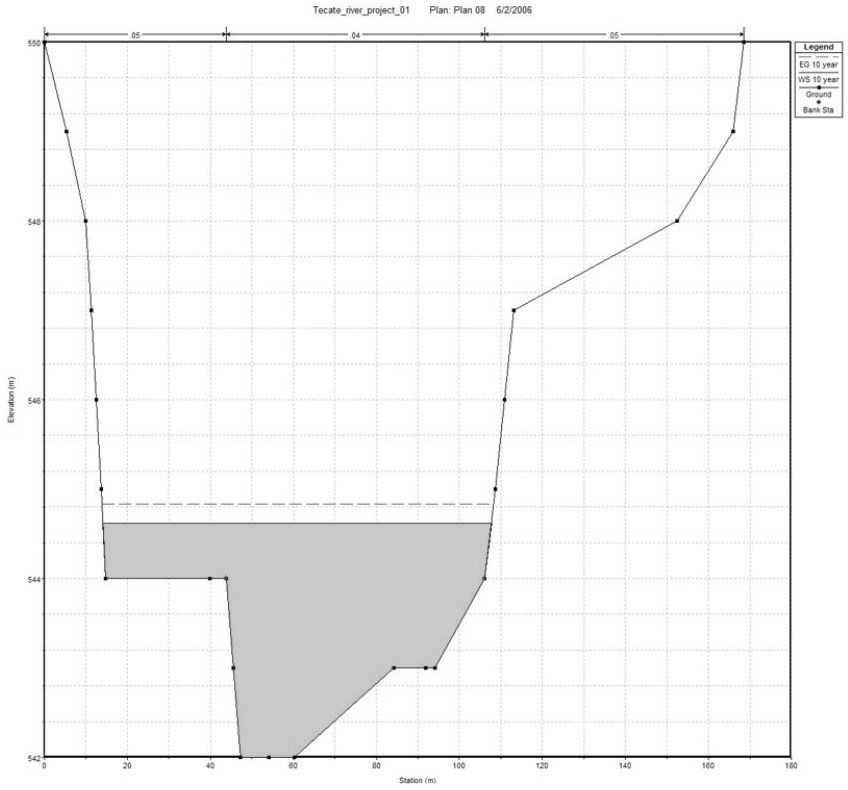

Figure 26. Calculated cross section at RM 10+360, 10-yr frequency

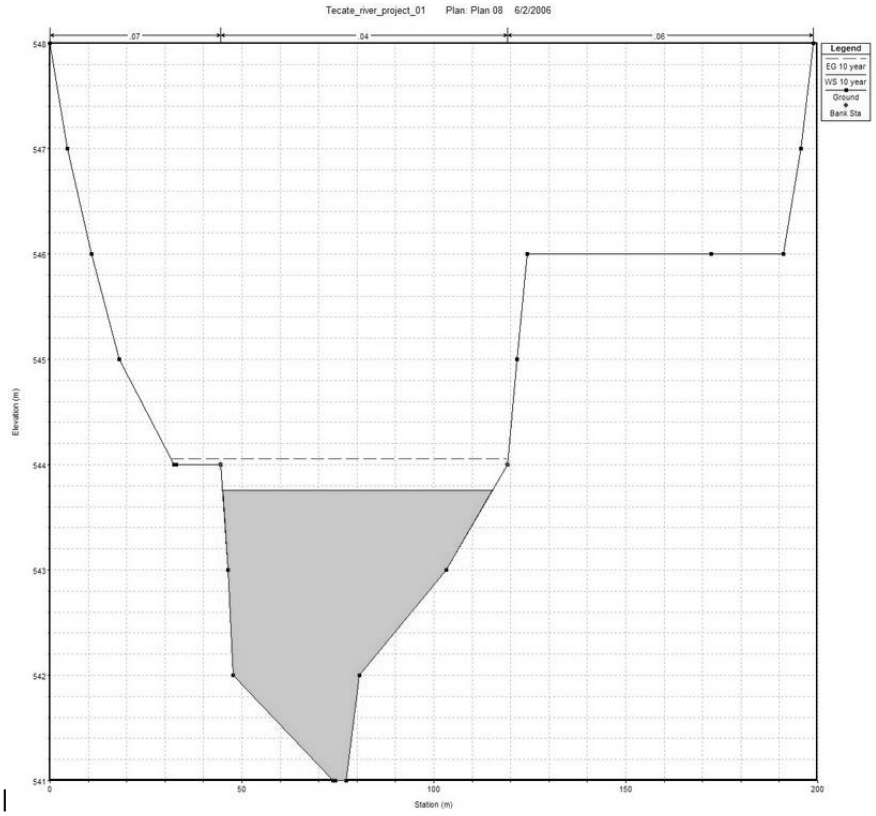

Figure 27. Calculated cross section at RM 10+160, 10-yr frequency

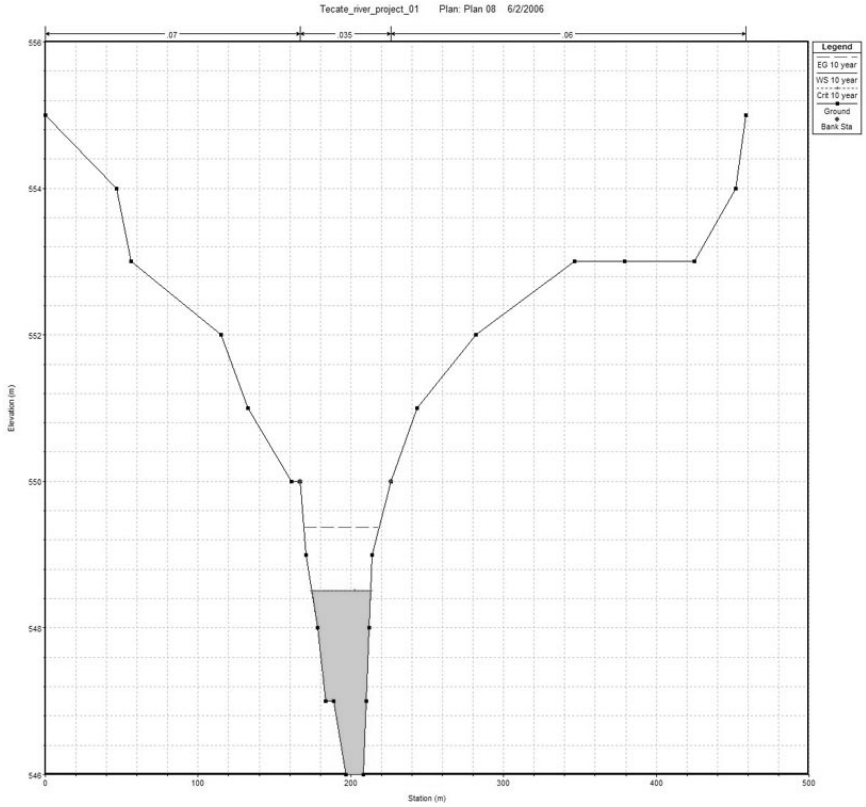

Figure 28. Calculated cross section at RM 9+960, 10-yr frequency

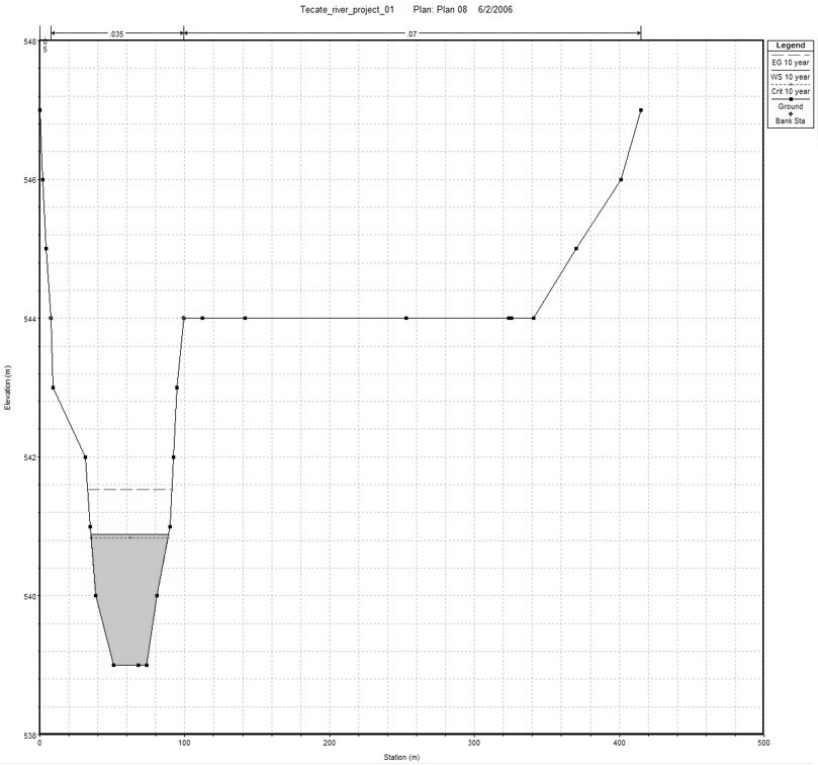

Figure 29. Calculated cross section at RM 9+760, 10-yr frequency.

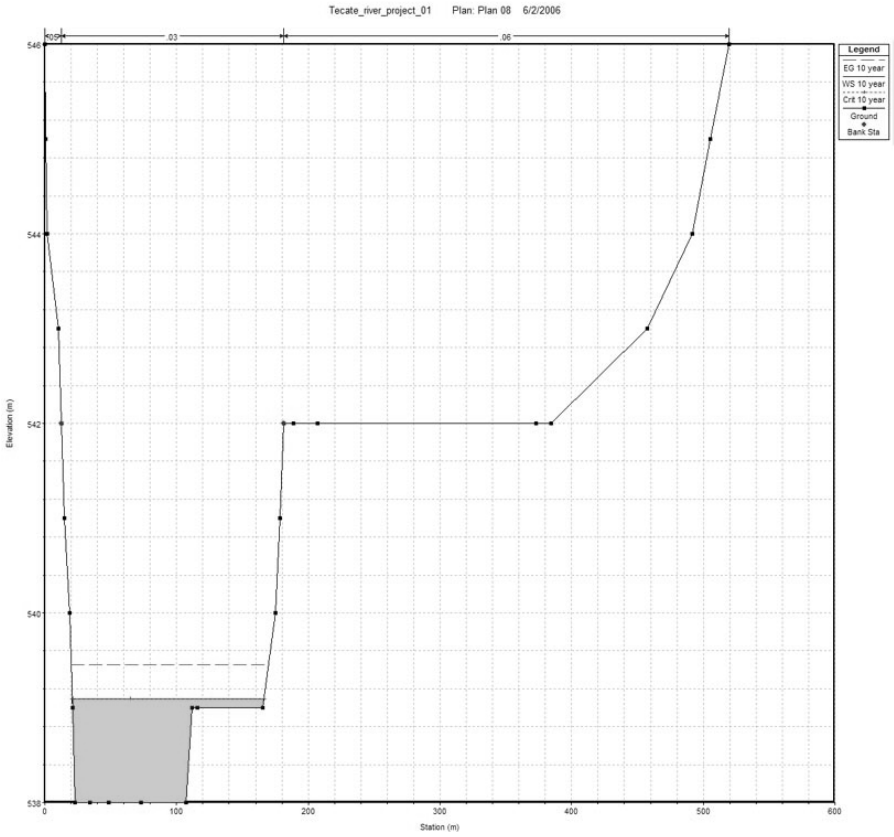

Figure 30. Calculated cross section at RM 9+560, 10-yr frequency

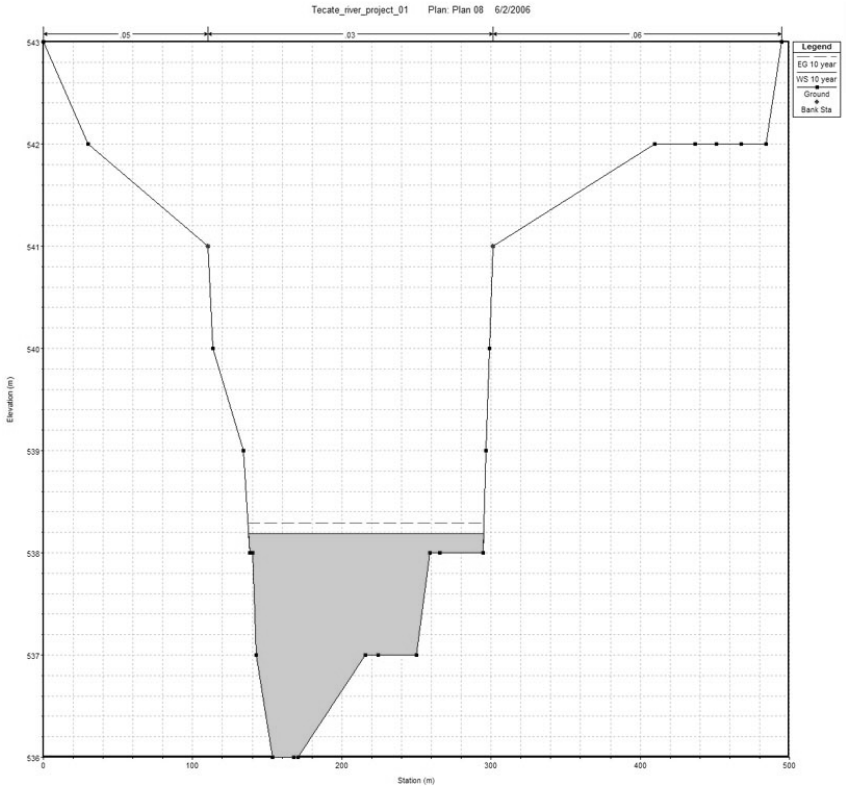

Figure 31. Calculated cross section at RM 9+360, 10-yr frequency

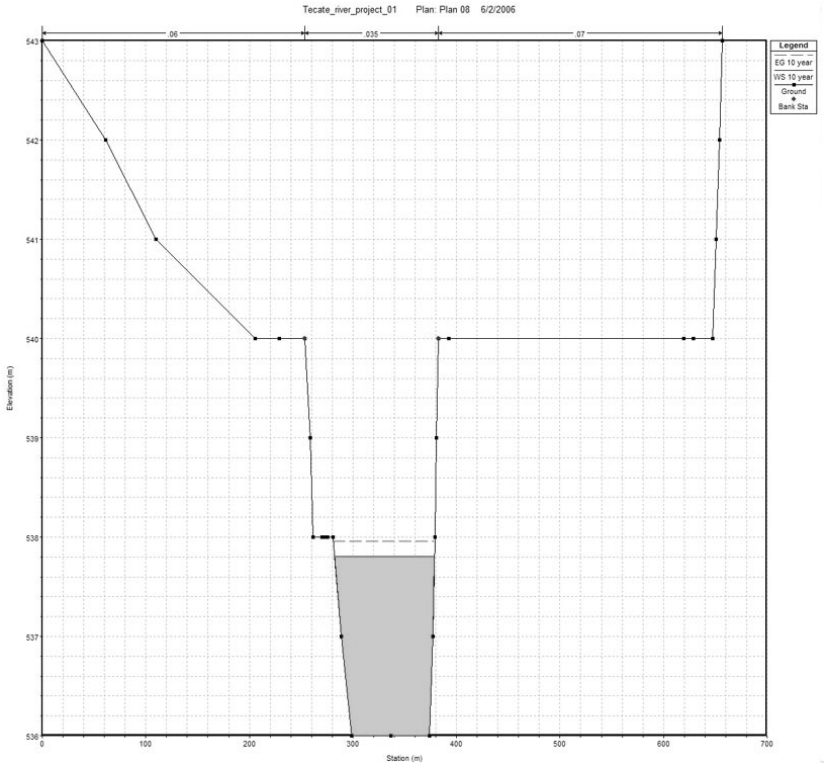

Figure 32. Calculated cross section at RM 9+160, 10-yr frequency

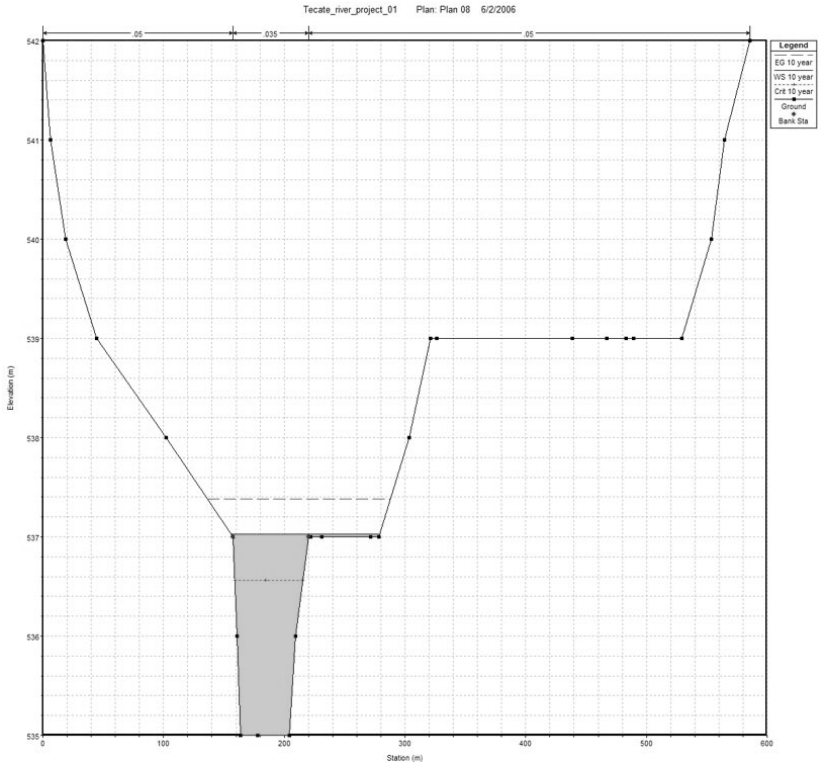

Figure 33. Calculated cross section at RM 8+960, 10-yr frequency

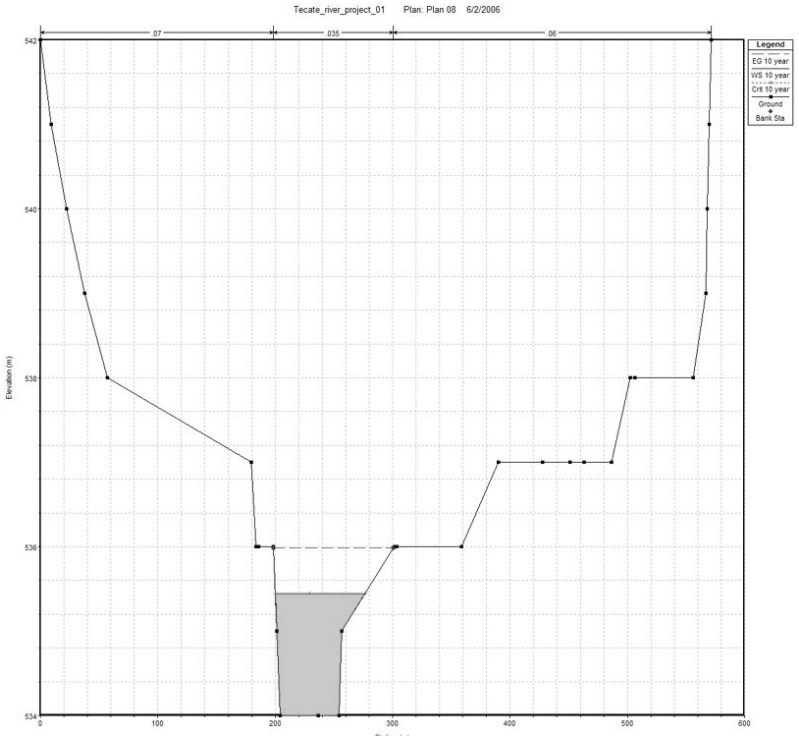

Figure 34. Calculated cross section at RM 08+760, 10-yr frequency

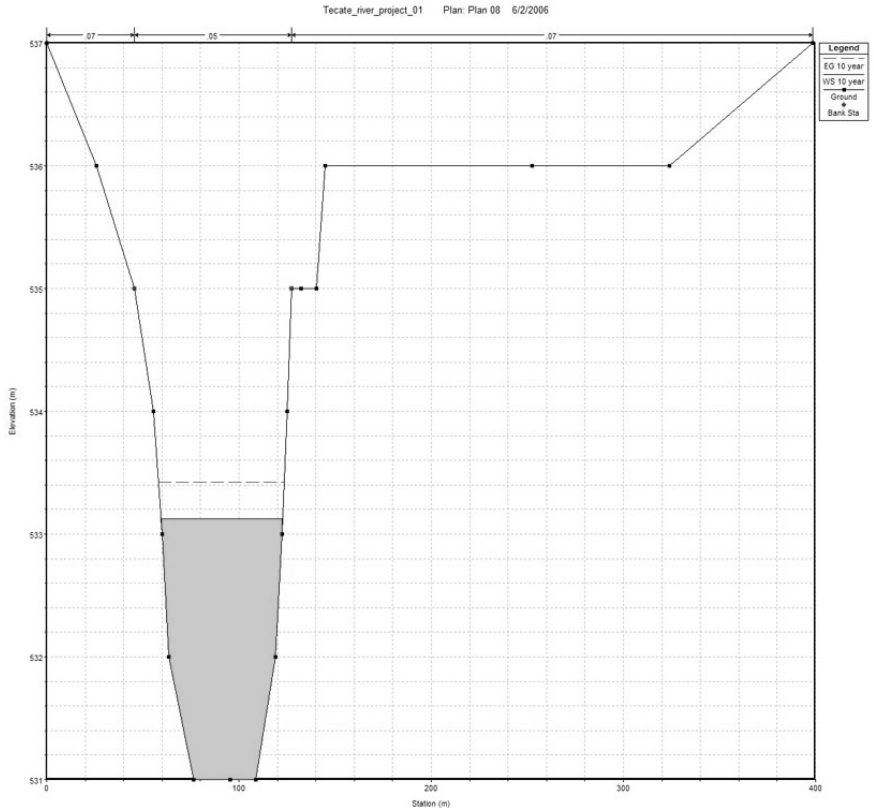

Figure 35. Calculated cross section at RM 8+560, 10-yr frequency

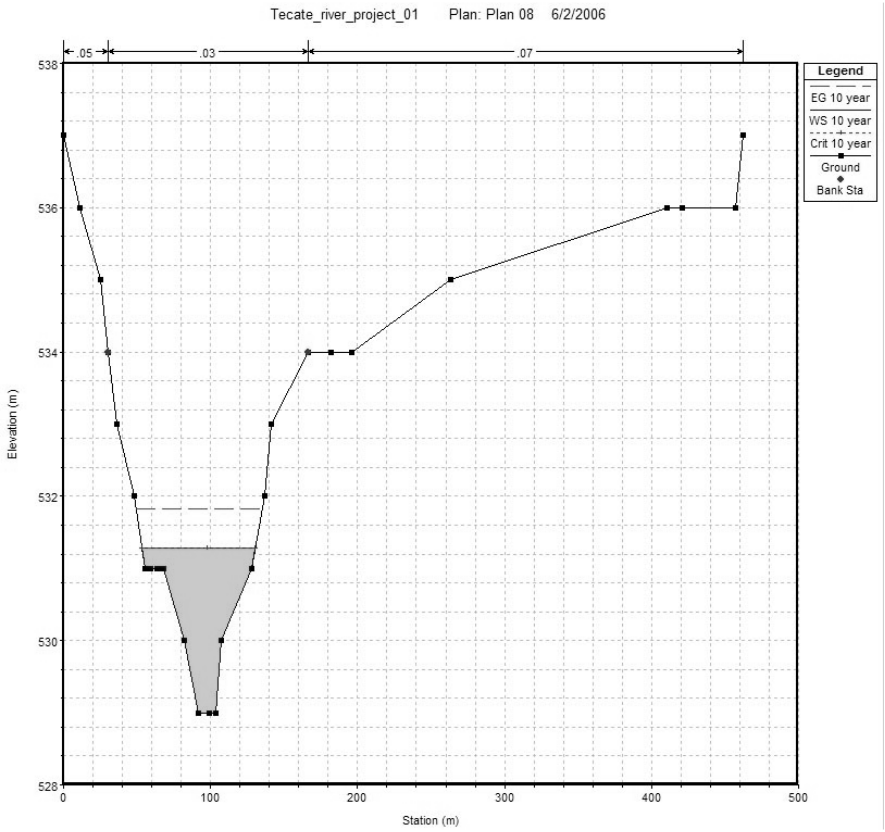

Figure 36. Calculated cross section at RM 8+360, 10-yr frequency

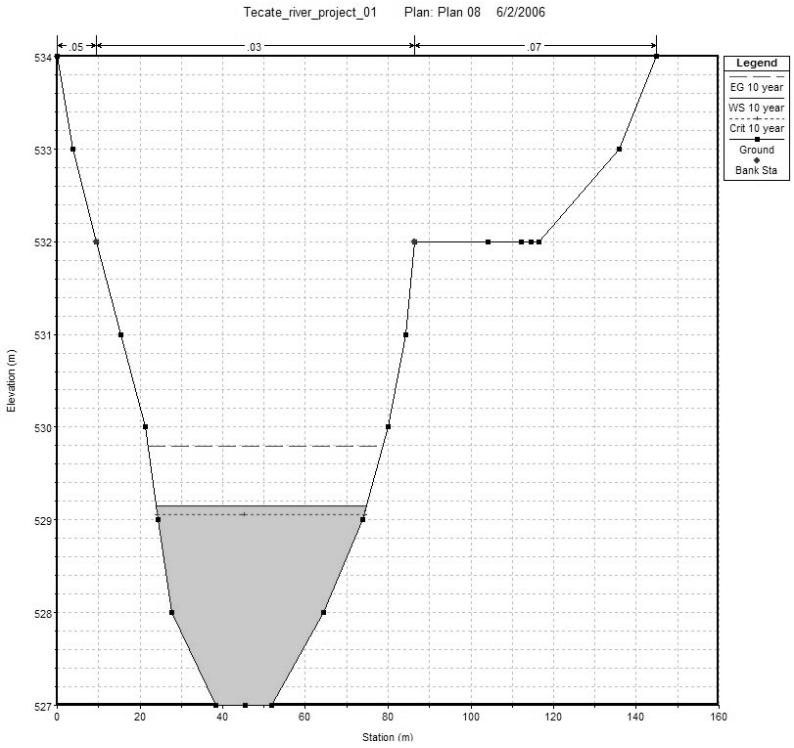

Figure 37. Calculated cross section at RM 8+160, 10-yr frequency

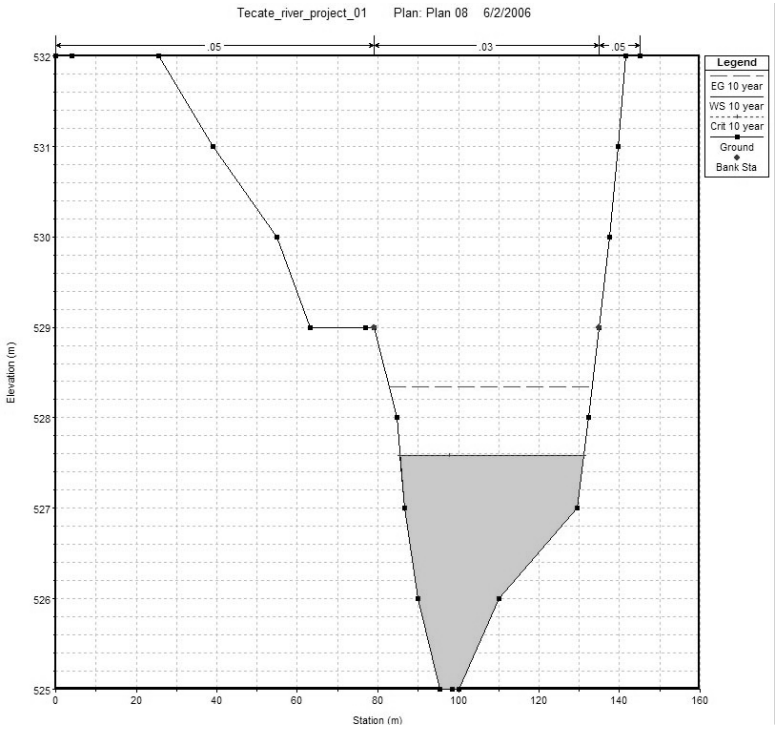

Figure 38. Calculated cross section at RM 7+960, 10-yr frequency

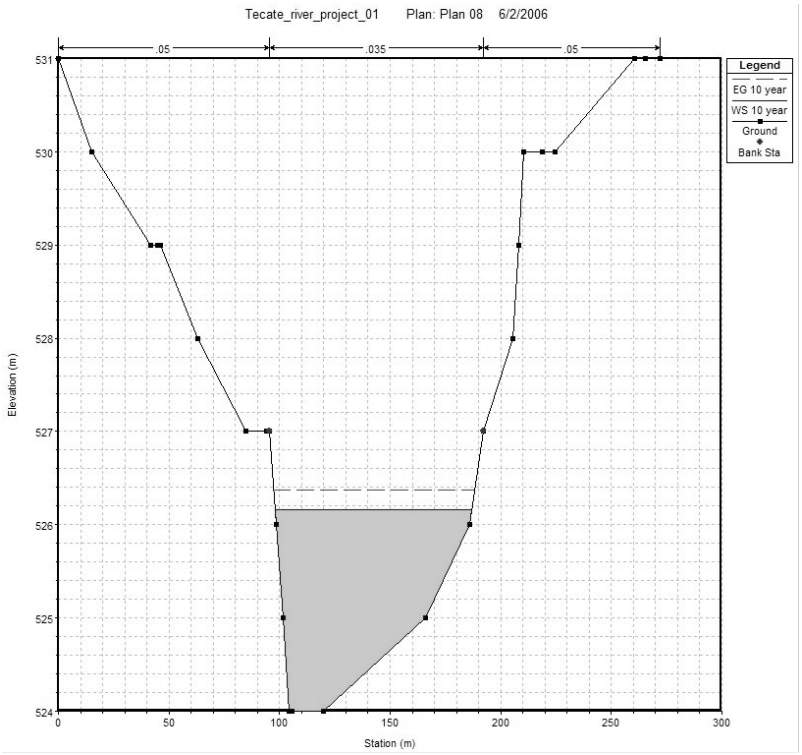

Figure 39. Calculated cross section at RM 7+760, 10-yr frequency

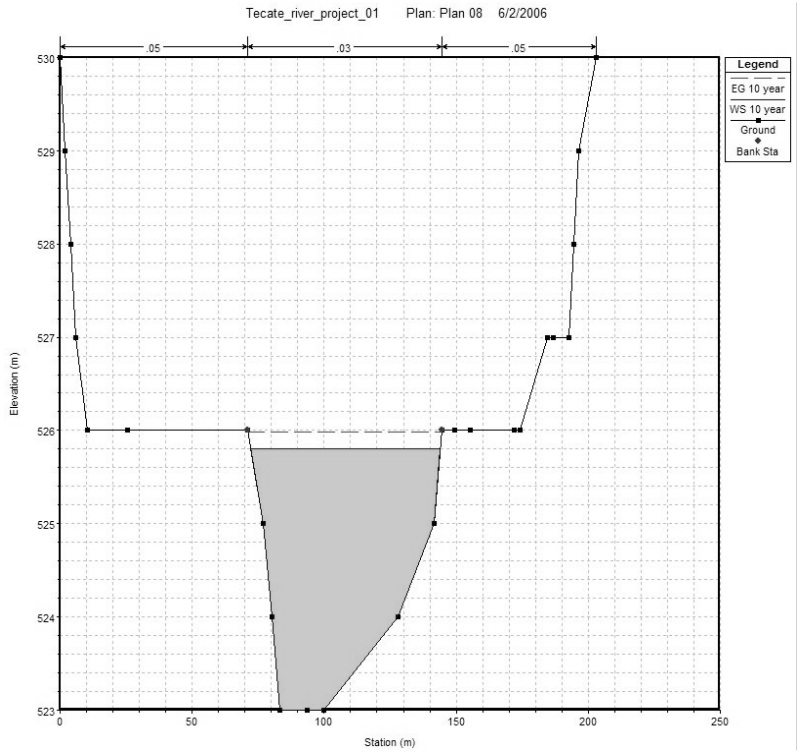

Figure 40. Calculated cross section at RM 7+560, 10-yr frequency

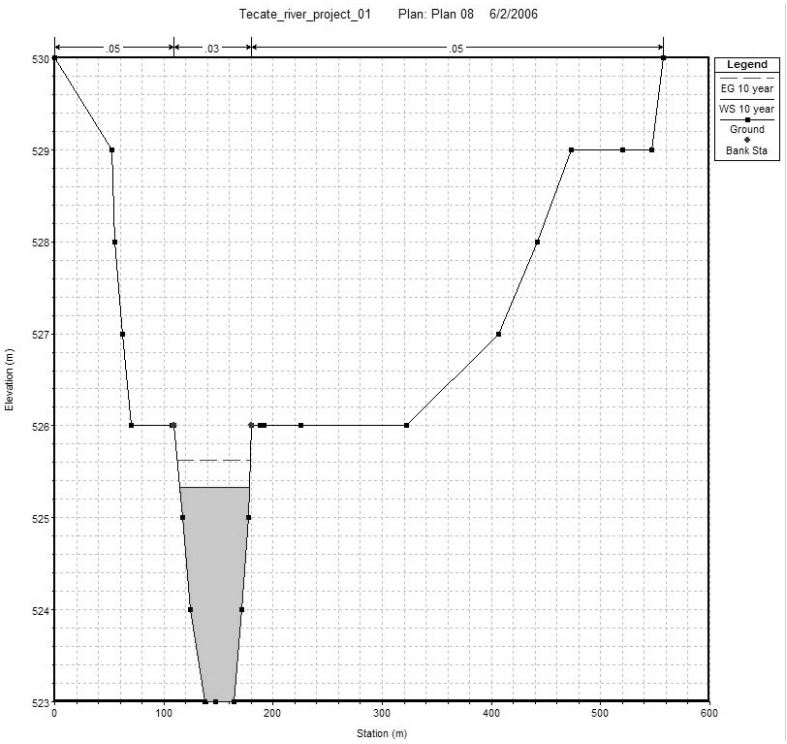

Figure 41. Calculated cross section at RM 7+360, 10-yr frequency

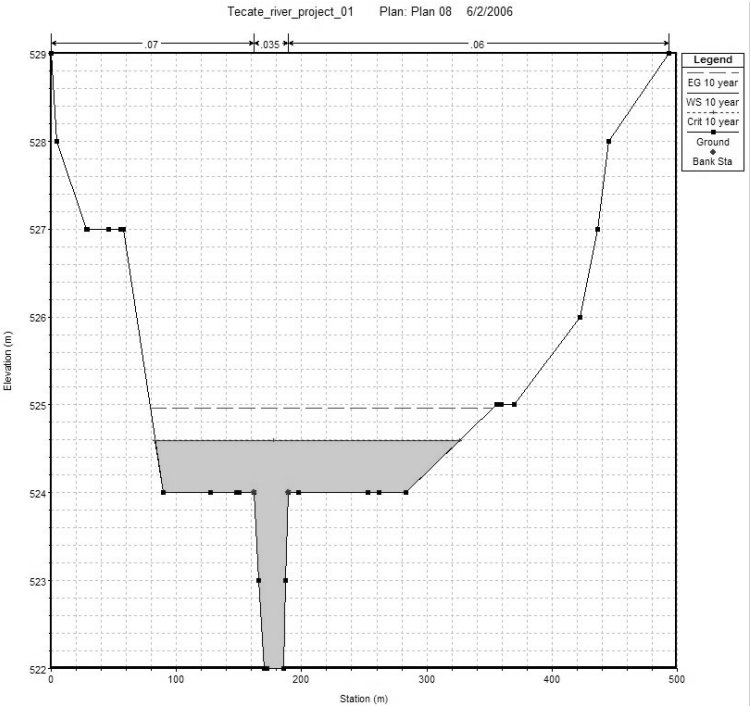

Figure 42. Calculated cross section at RM 7+160, 10-yr frequency

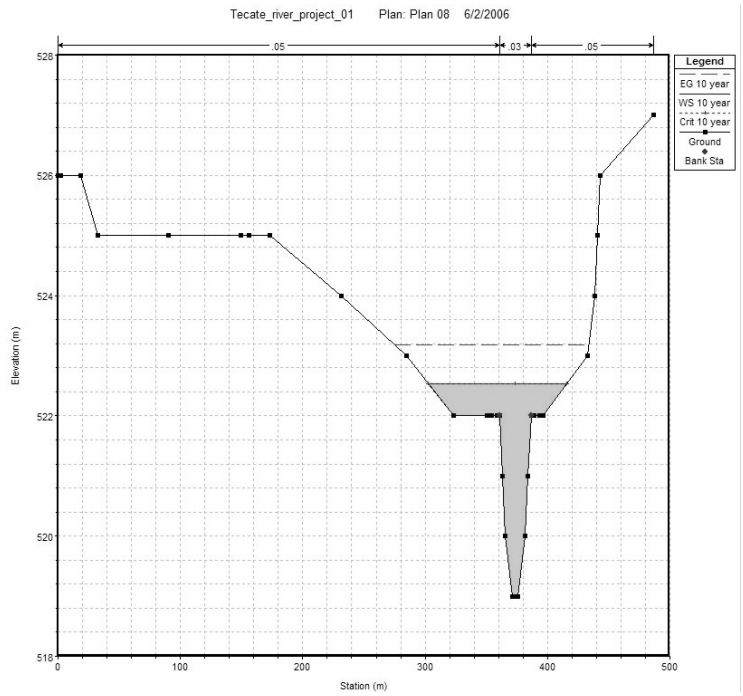

Figure 43. Calculated cross section at RM 6+960, 10-yr frequency

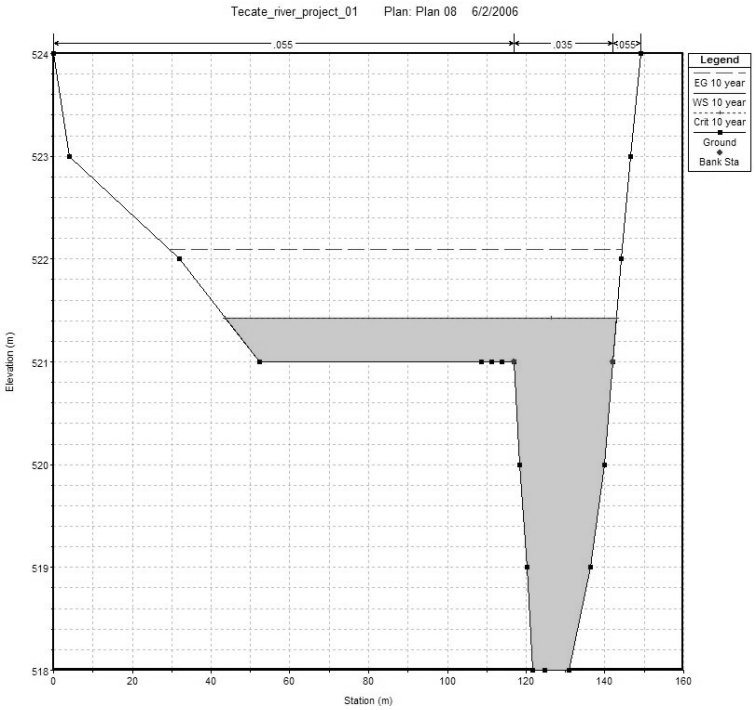

Figure 44. Calculated cross section at RM 6+760, 10-yr frequency

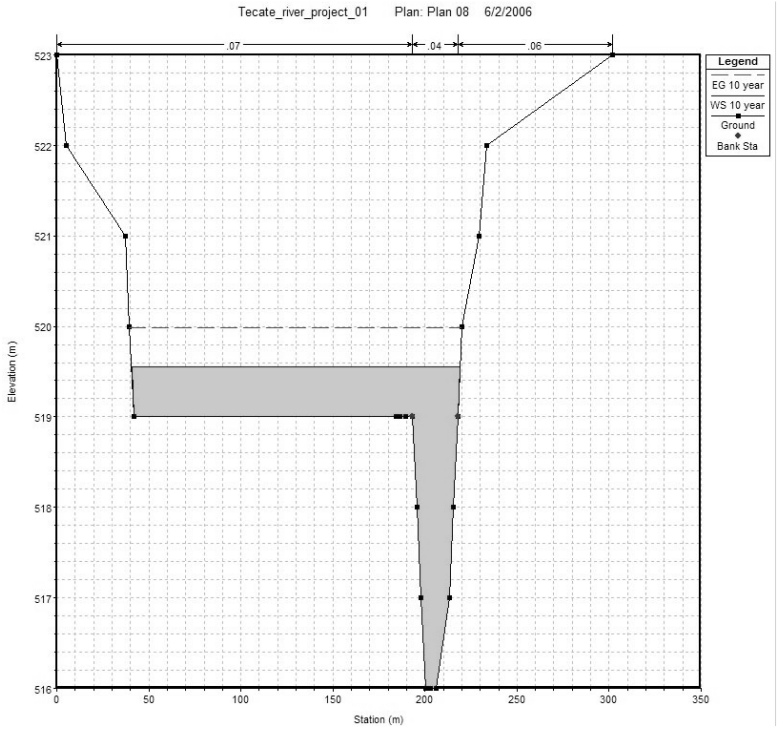

Figure 45. Calculated cross section at RM 6+560, 10-yr frequency

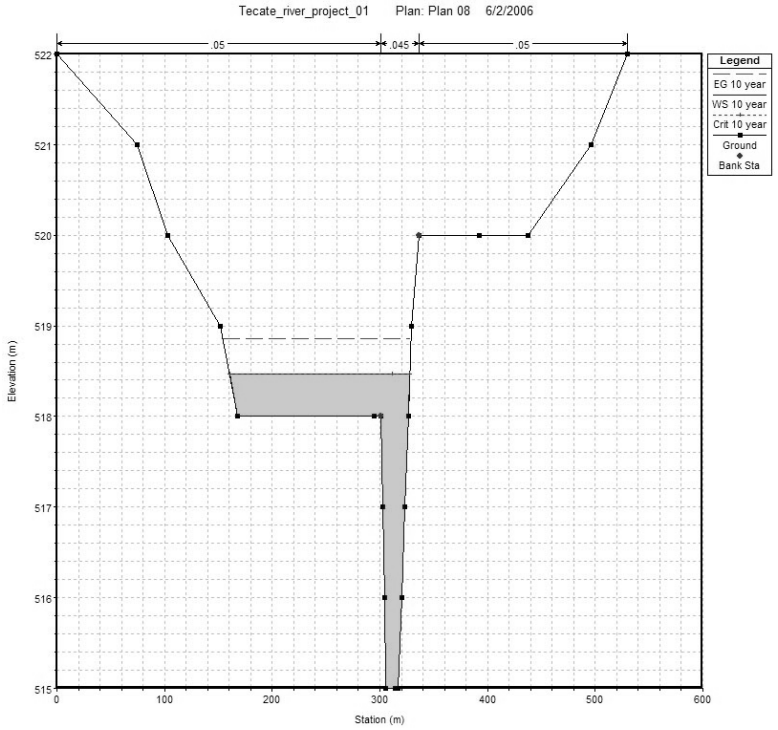

Figure 46. Calculated cross section at RM 06+360, 10-yr frequency

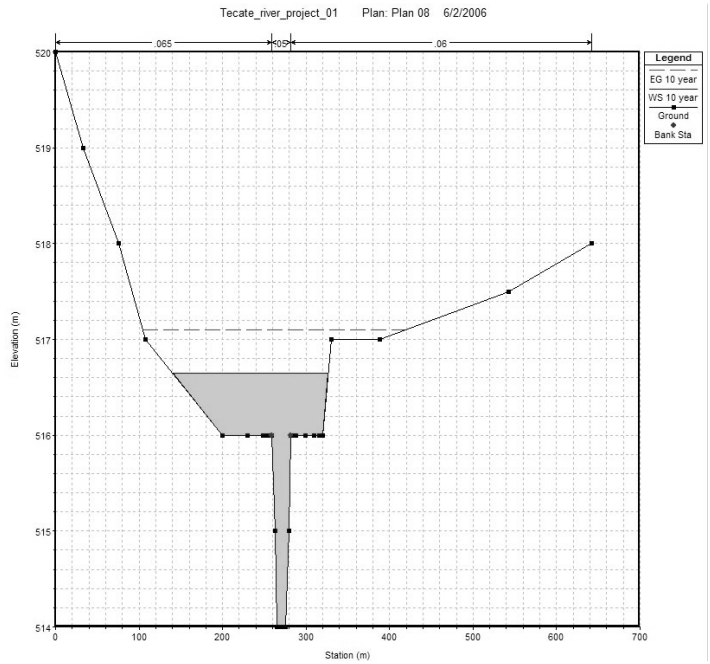

Figure 47. Calculated cross section at RM 6+160, 10-yr frequency

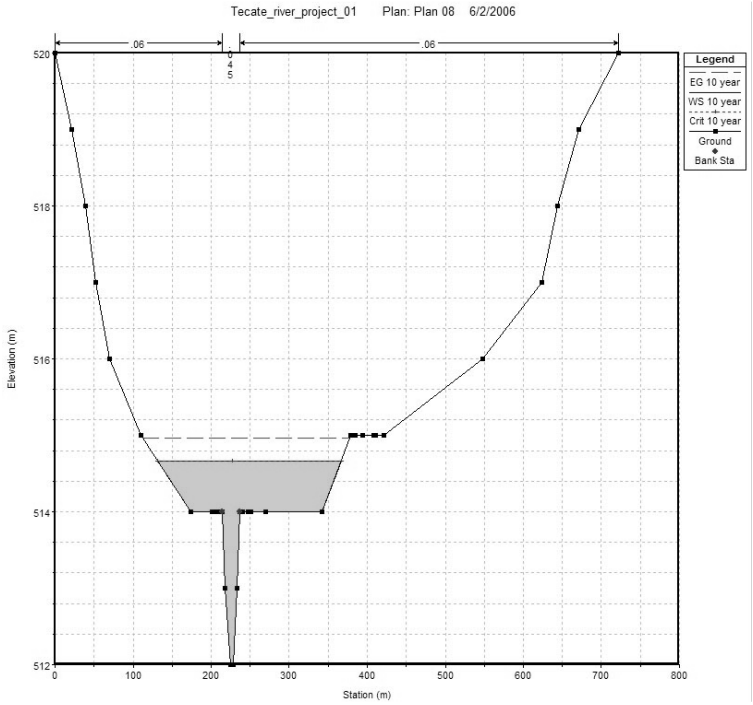

Figure 48. Calculated cross section at RM 5+960, 10-yr frequency

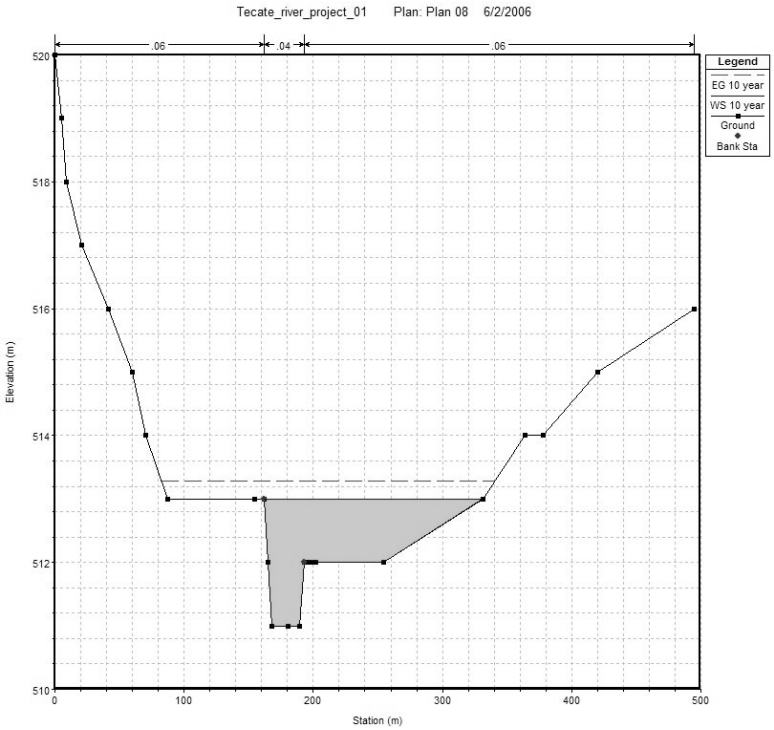

Figure 49. Calculated cross section at RM 5+760, 10-yr frequency

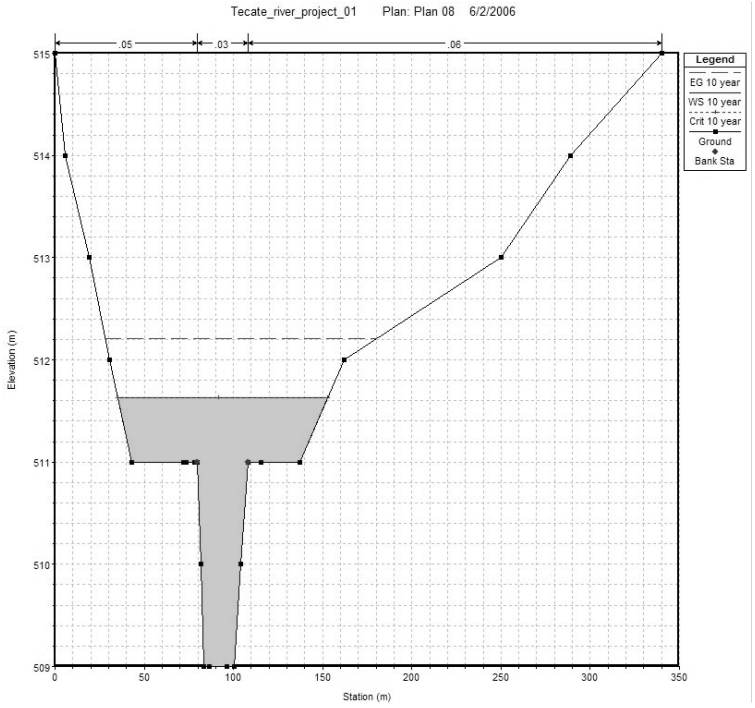

Figure 50. Calculated cross section at RM 5+560, 10-yr frequency

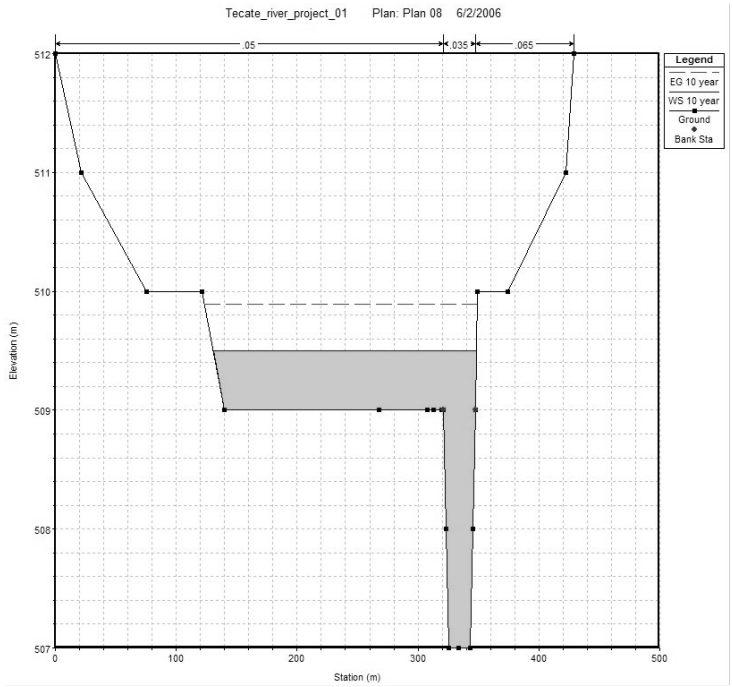

Figure 51. Calculated cross section at RM 5+360, 10-yr frequency

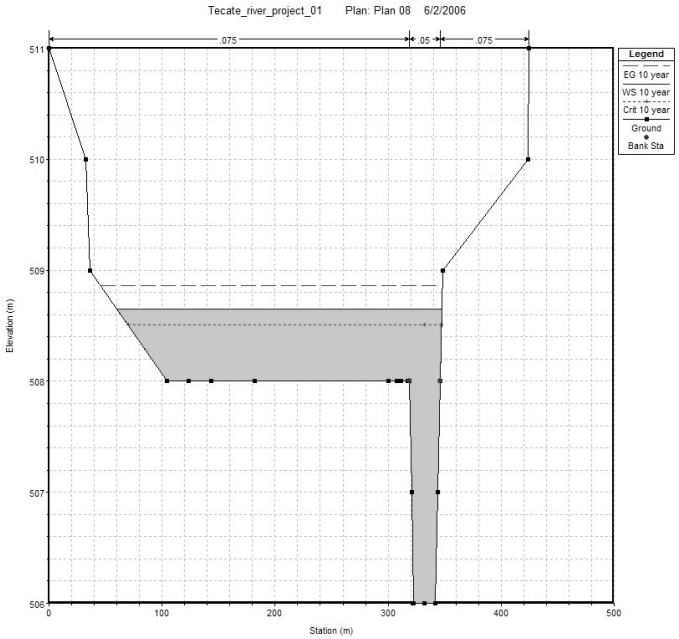

Figure 52. Calculated cross section at RM 5+160, 10-yr frequency

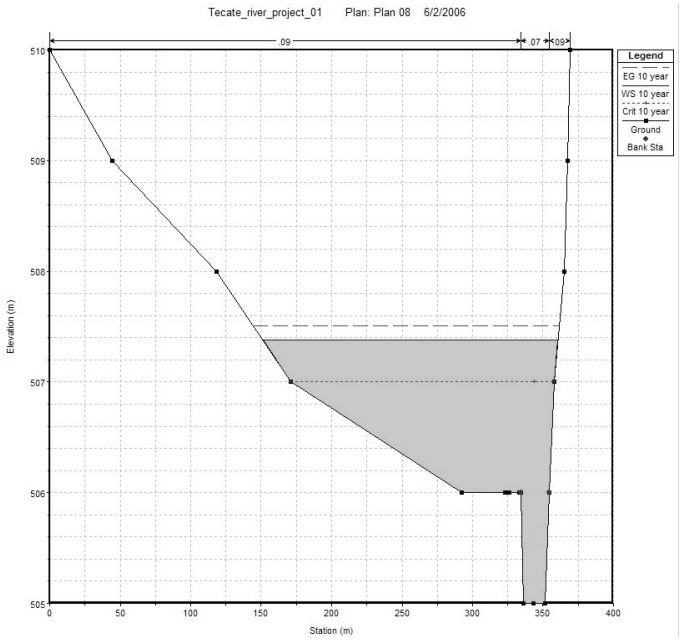

Figure 53. Calculated cross section at RM 4+960, 10-yr frequency

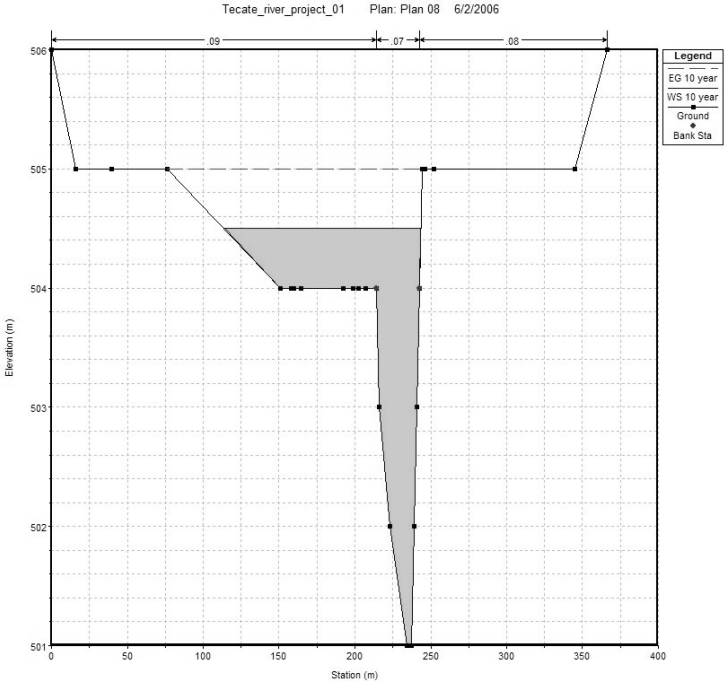

Figure 54. Calculated cross section at RM 4+760, 10-yr frequency

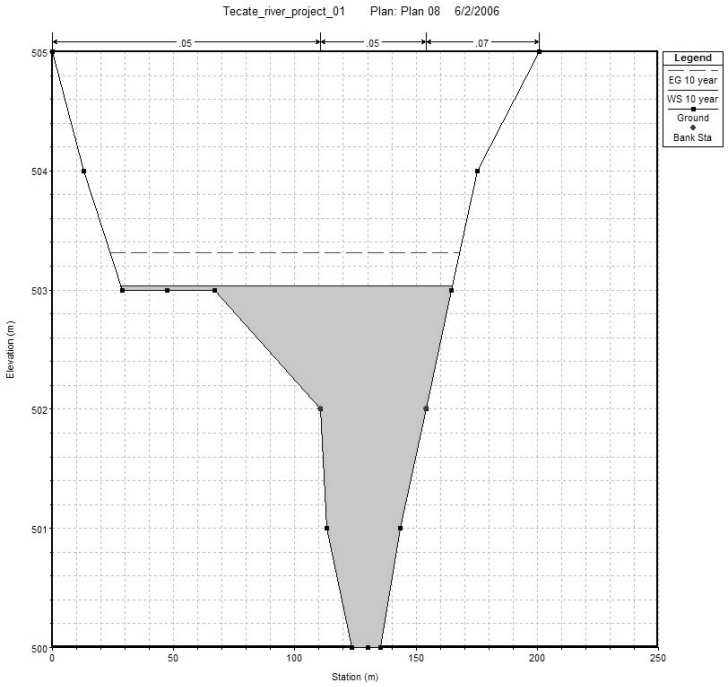

Figure 55. Calculated cross section at RM 4+560, 10-yr frequency

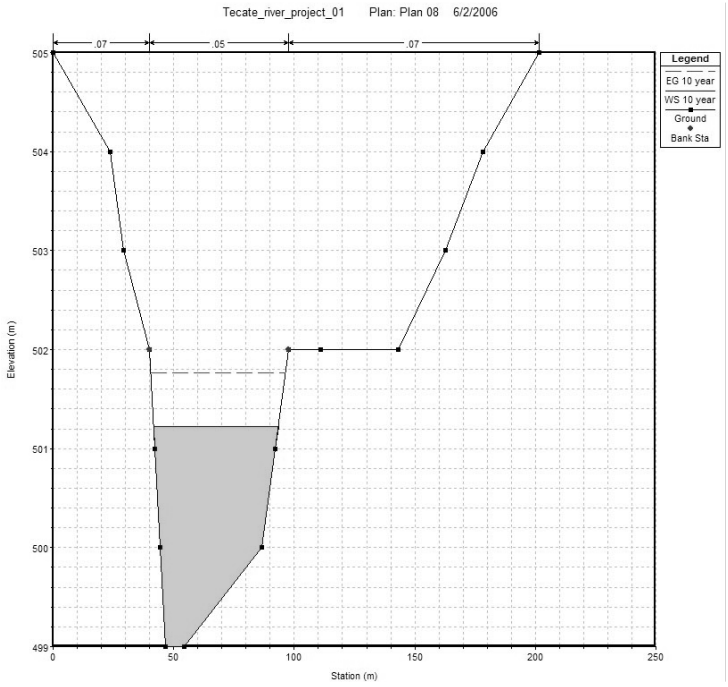

Figure 56. Calculated cross section at RM 4+360, 10-yr frequency

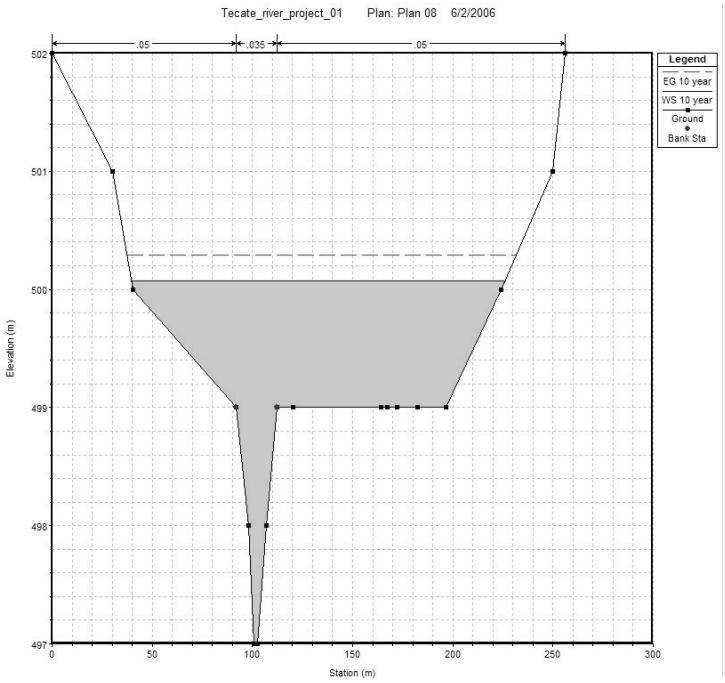

Figure 57. Calculated cross section at RM 4+160, 10-yr frequency

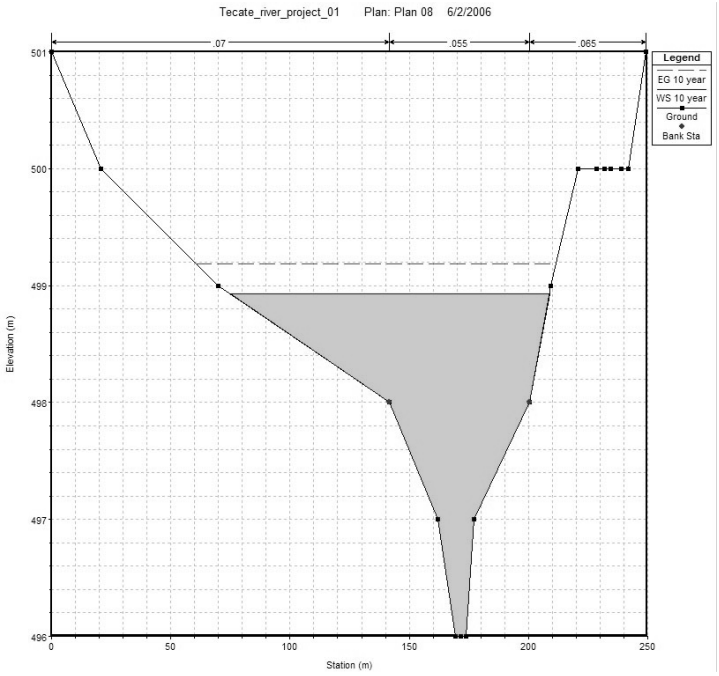

Figure 58. Calculated cross section at RM 3+960, 10-yr frequency

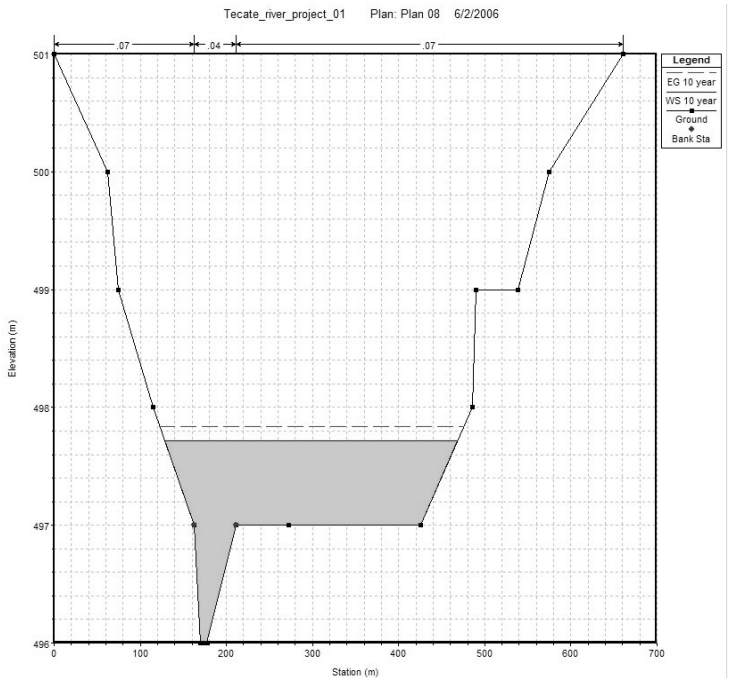

Figure 59. Calculated cross section at RM 3+760, 10-yr frequency

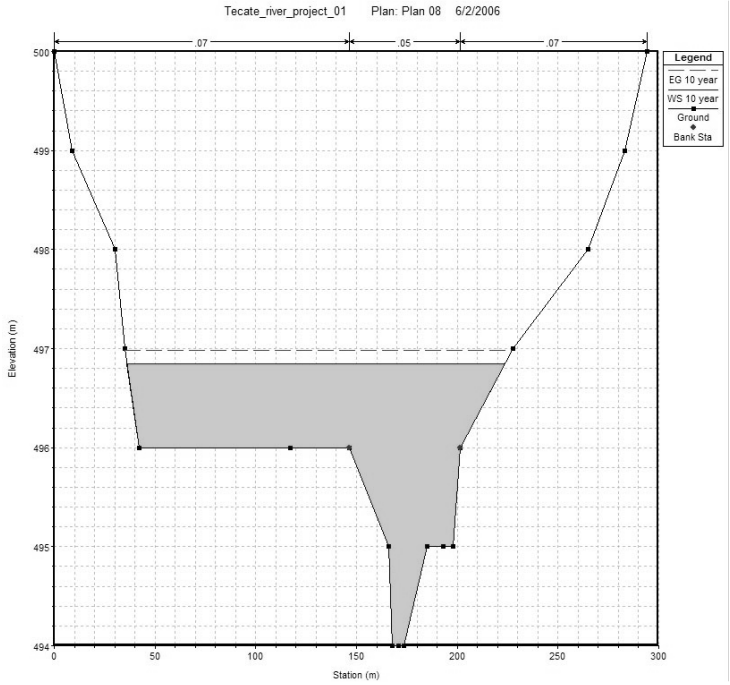

Figure 60. Calculated cross section at RM 3+560, 10-yr frequency

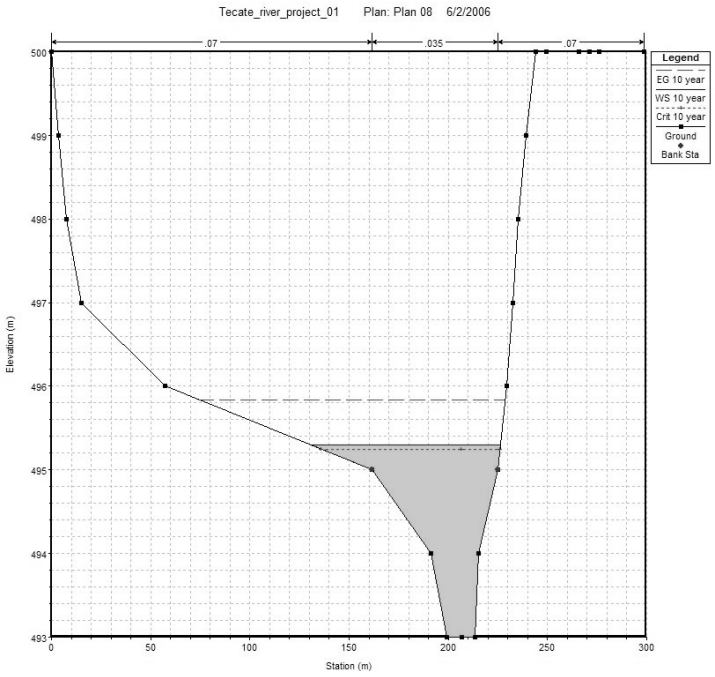

Figure 61. Calculated cross section at RM 3+360, 10-yr frequency

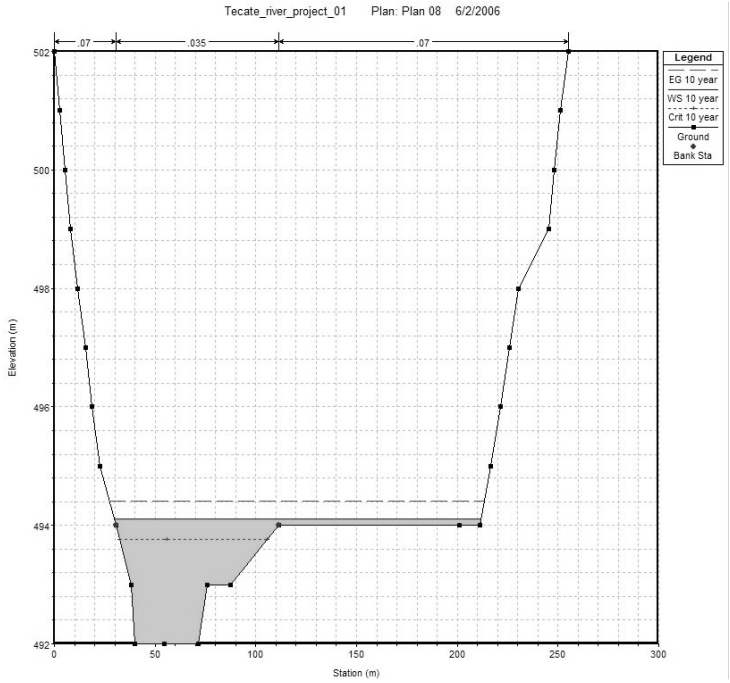

Figure 62. Calculated cross section at RM 3+160, 10-yr frequency

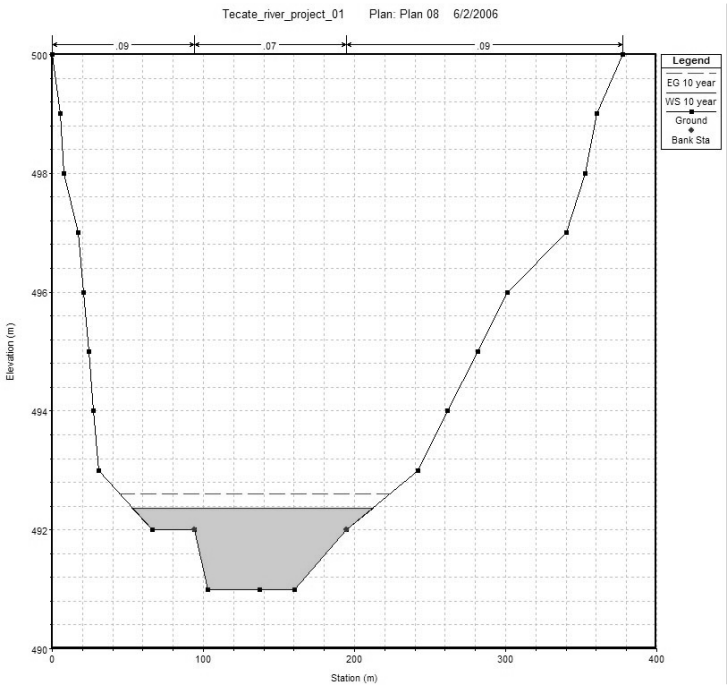

Figure 63. Calculated cross section at RM 2+960, 10-yr frequency

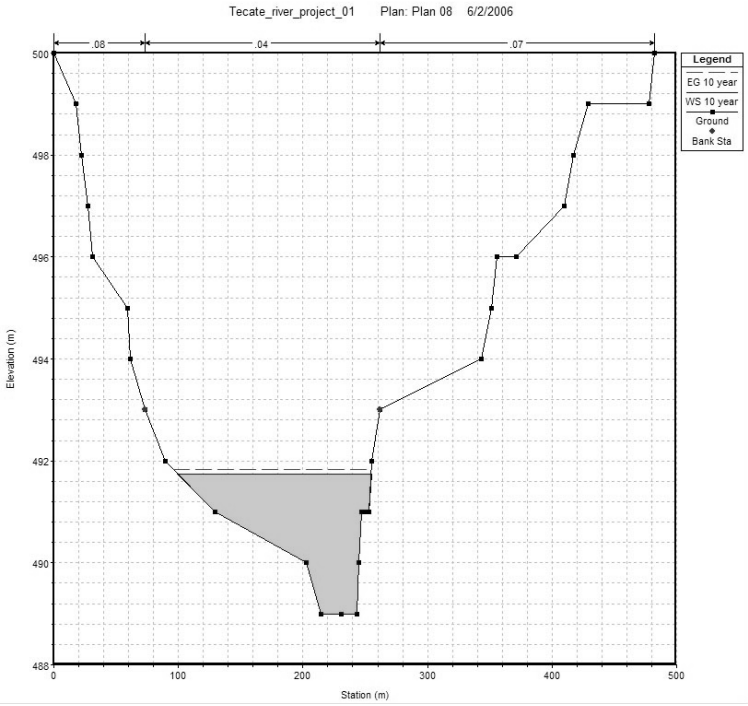

Figure 64. Calculated cross section at RM 2+760, 10-yr frequency

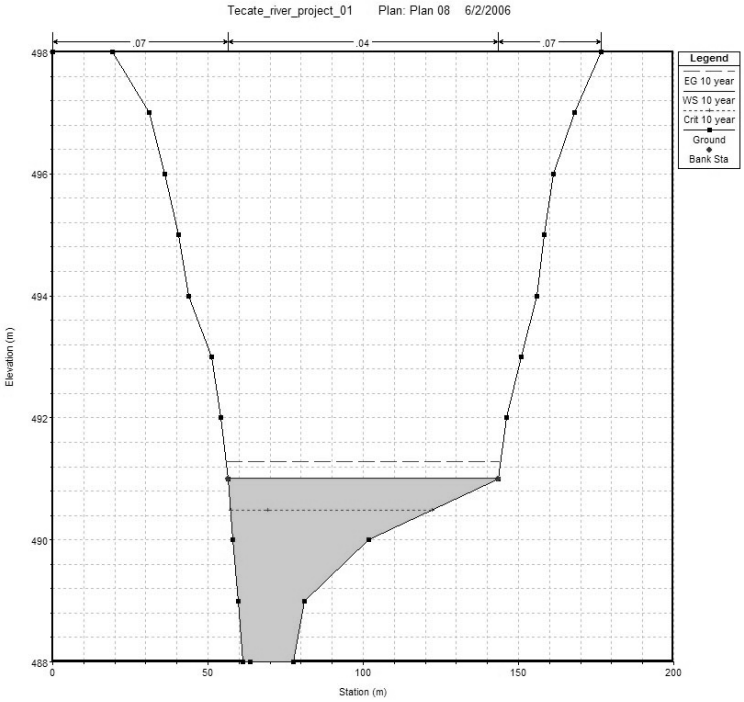

Figure 65. Calculated cross section at RM 2+560, 10-yr frequency

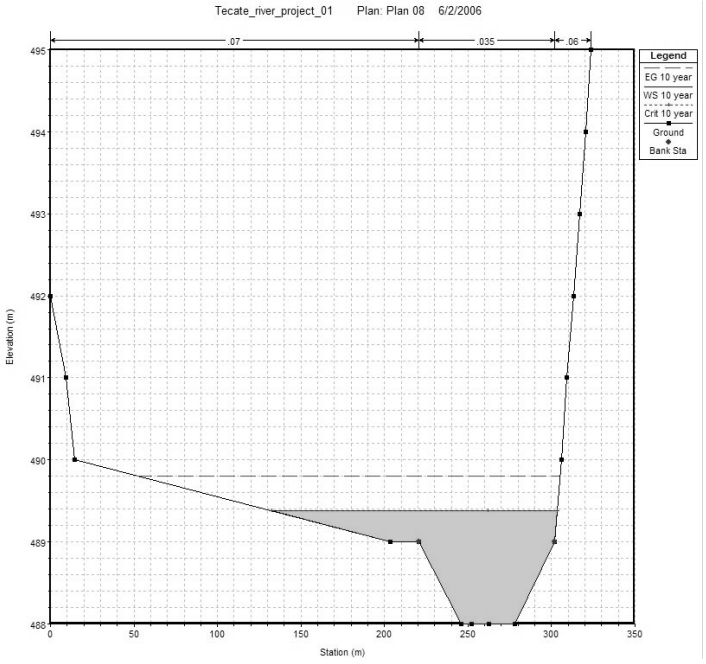

Figure 66. Calculated cross section at RM 2+360, 10-yr frequency

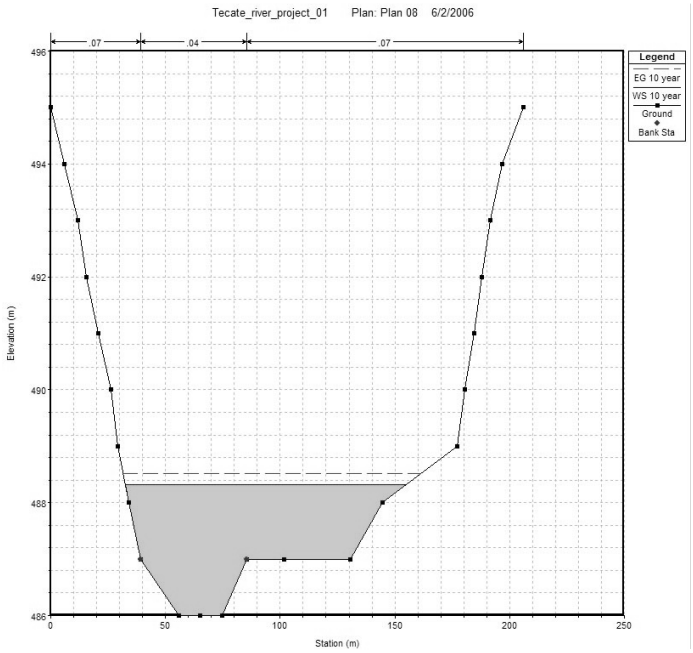

Figure 67. Calculated cross section at RM 2+160, 10-yr frequency

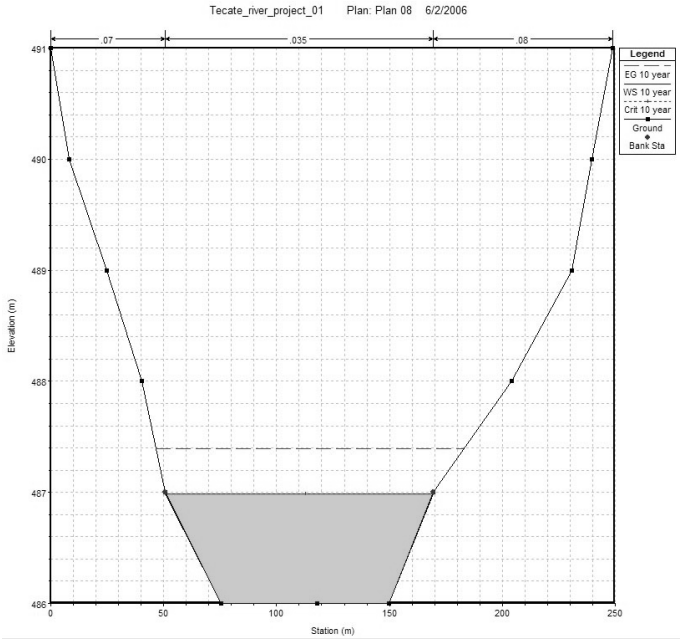

Figure 68. Calculated cross section at RM 1+960, 10-yr frequency

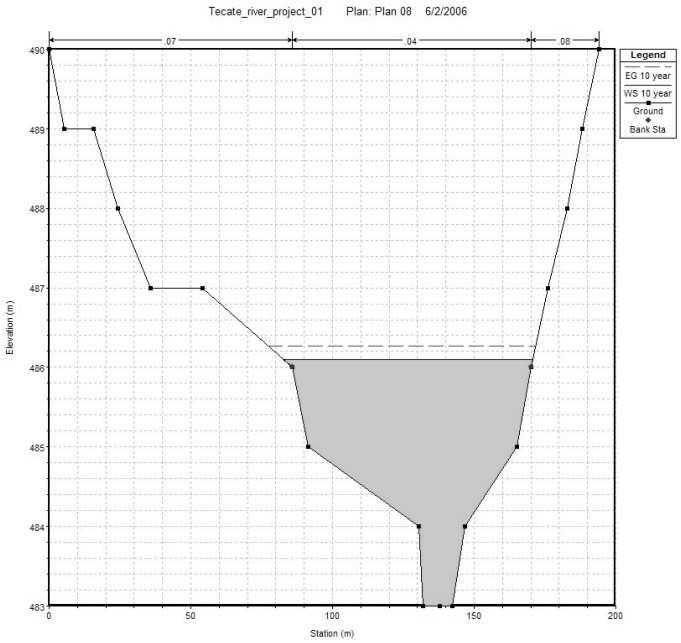

Figure 69. Calculated cross section at RM 1+760, 10-yr frequency

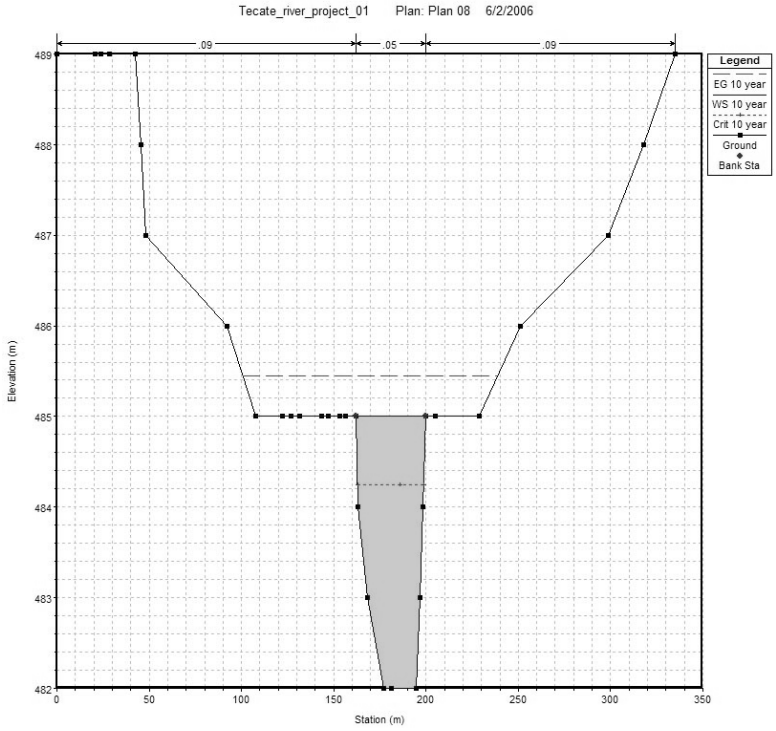

Figure 70. Calculated cross section at RM 1+560, 10-yr frequency

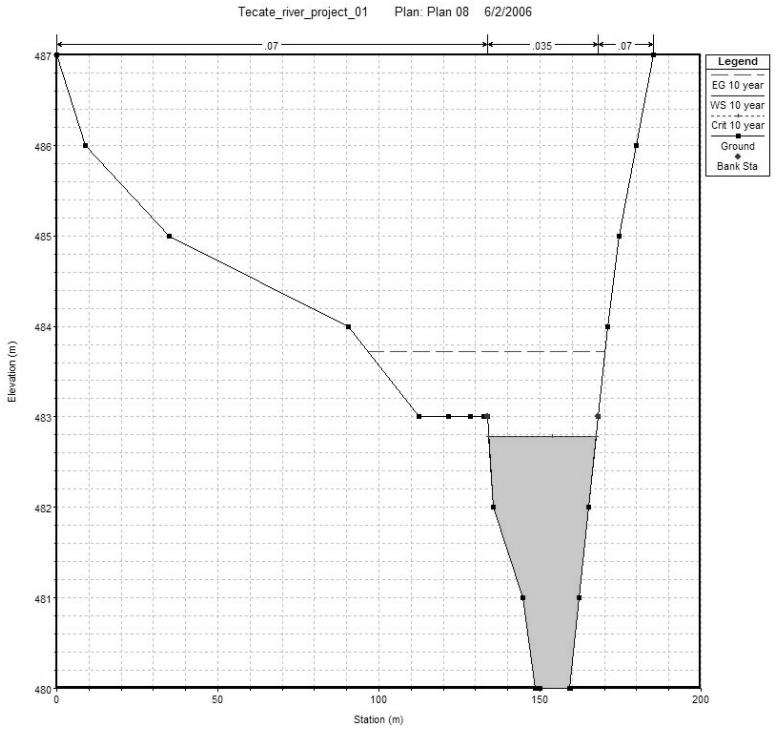

Figure 71. Calculated cross section at RM 1+360, 10-yr frequency

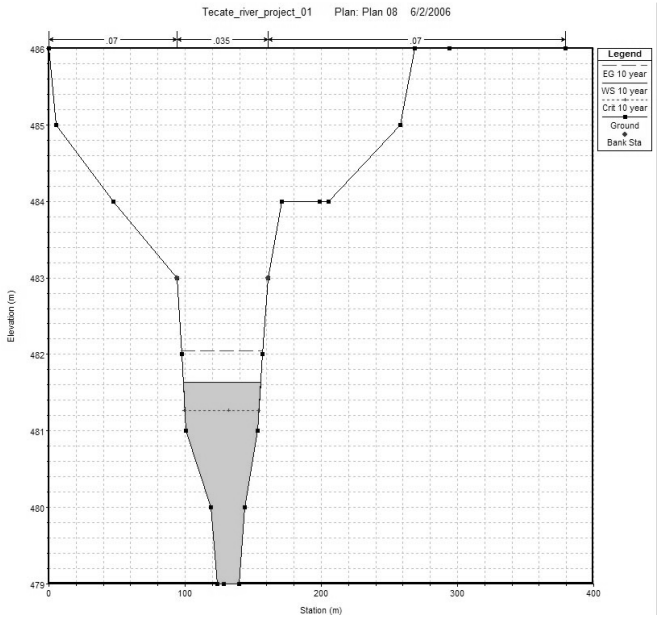

Figure 72. Calculated cross section at RM 1+160, 10-yr frequency

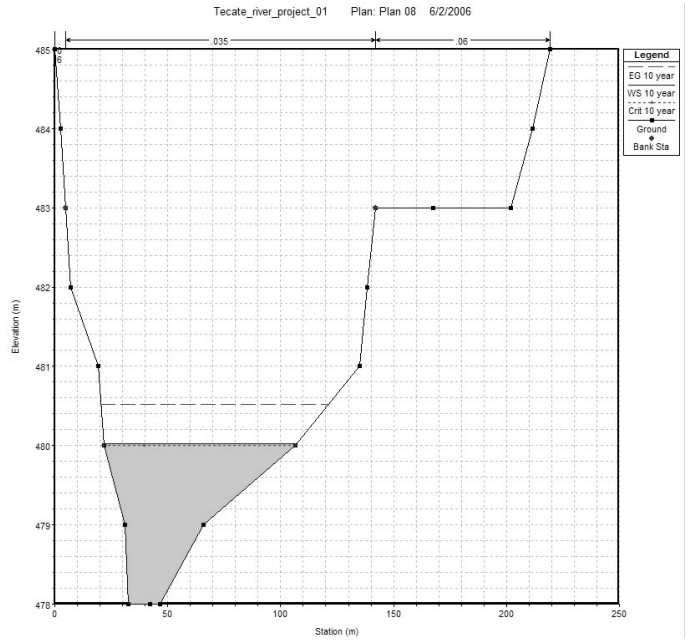

Figure 73. Calculated cross section at RM 0+960, 10-yr frequency

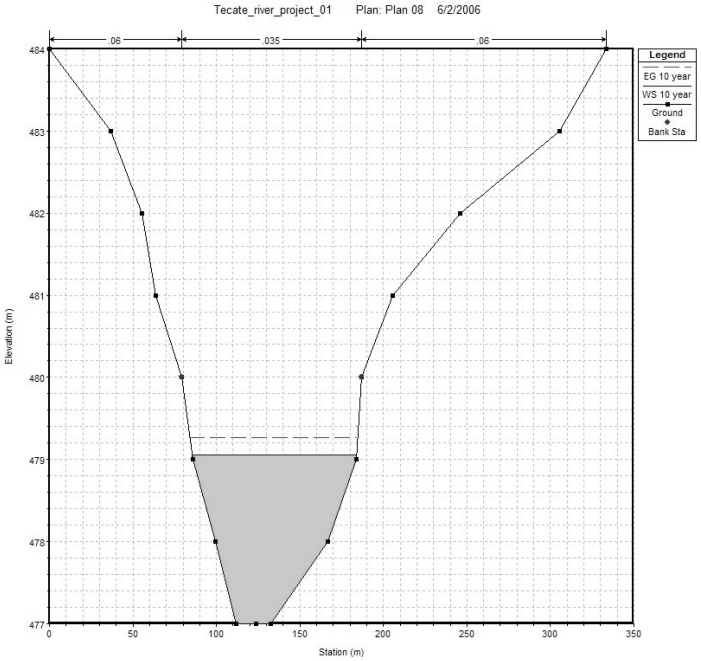

Figure 74. Calculated cross section at RM 0+760, 10-yr frequency

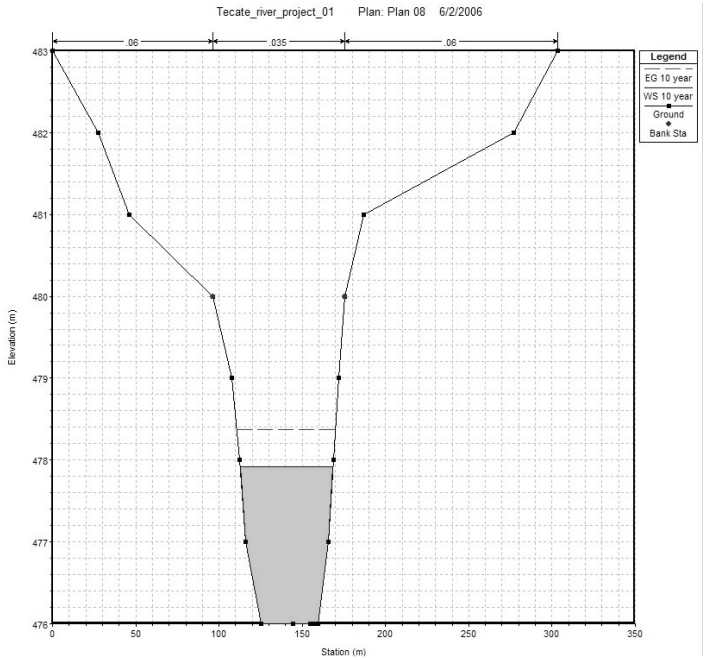

Figure 75. Calculated cross section at RM 0+560, 10-yr frequency

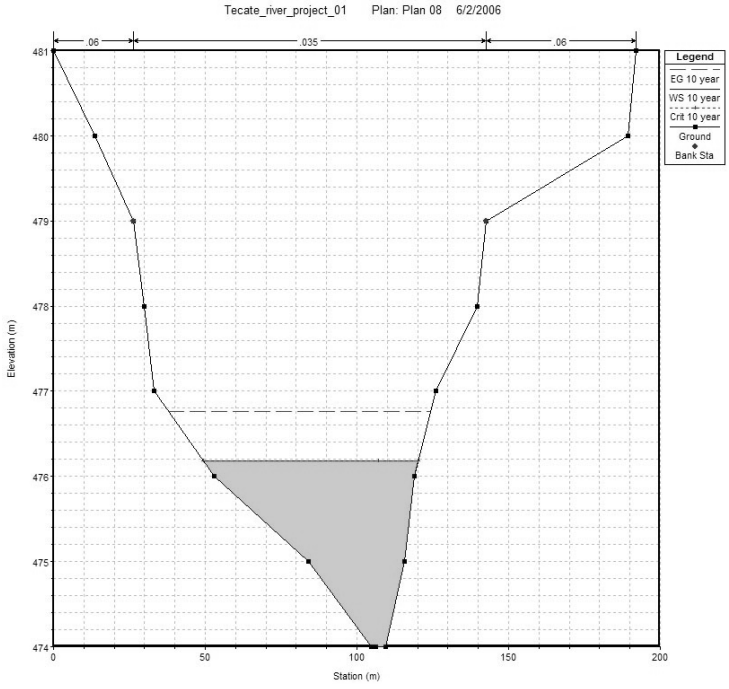

Figure 76. Calculated cross section at RM 0+360, 10-yr frequency

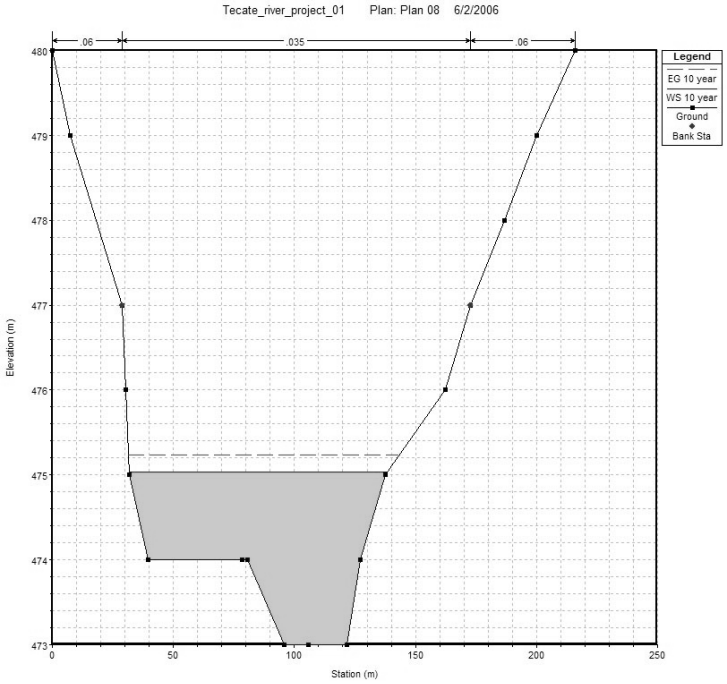

Figure 77. Calculated cross section at RM 0+160, 10-yr frequency

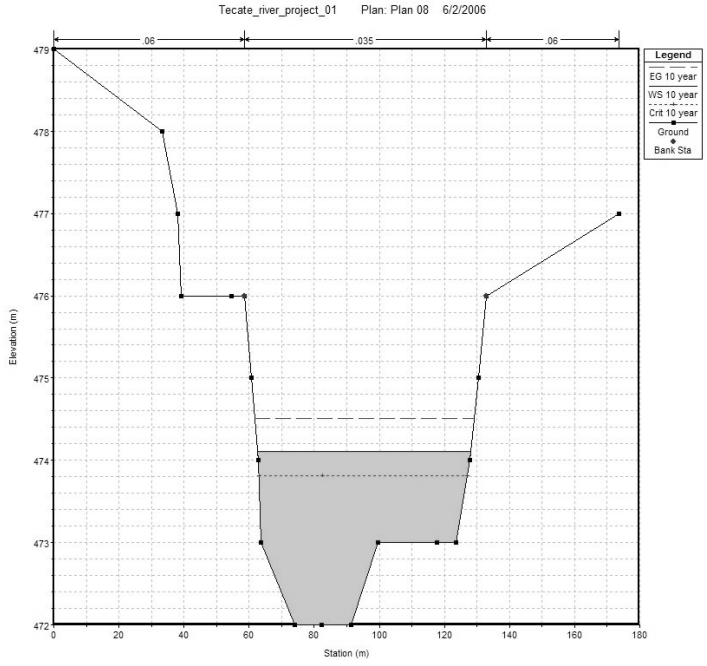

Figure 78. Calculated cross section at RM 0+000, 10-yr frequency

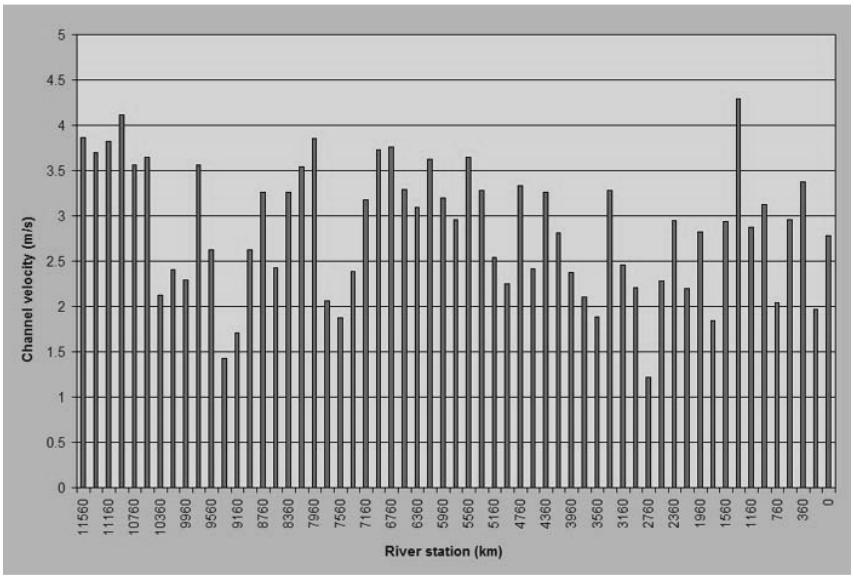

Figure 79. HEC-RAS channel velocities, 10-yr frequency

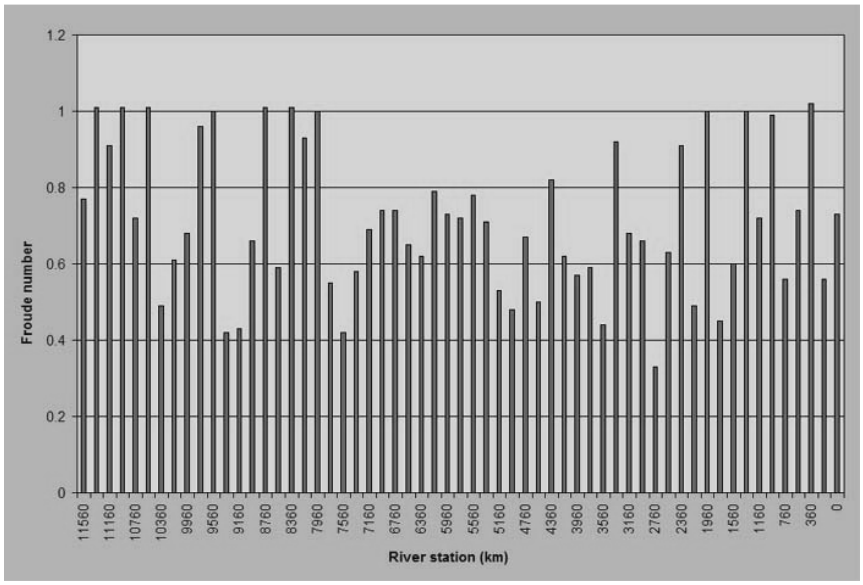

Figure 80. HEC-RAS Froude numbers, 10-yr frequency

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Tecate	11560	10 year	268.00	552.00	555.67	555.67	556.36	0.004170	3.86	97.31	93.59	0.77
Tecate	11360	10 year	268.00	549.00	552.19	552.19	552.89	0.011424	3.70	72.50	53.13	1.01
Tecate	11160	10 year	268.00	548.00	550.23	550.09	550.97	0.006209	3.82	70.14	39.12	0.91
Tecate	10960	10 year	268.00	546.00	548.51	548.51	549.37	0.010540	4.11	65.16	38.40	1.01
Tecate	10760	10 year	268.00	544.00	546.93	546.64	547.53	0.004781	3.56	95.57	67.60	0.72
Tecate	10560	10 year	268.00	544.00	545.45	545.45	546.12	0.011231	3.65	73.50	54.91	1.01
Tecate	10360	10 year	268.00	542.00	544.62		544.84	0.003036	2.12	138.43	93.65	0.49
Tecate	10160	10 year	268.00	541.00	543.76		544.05	0.005096	2.41	111.31	70.28	0.61
Tecate	9960	10 year	268.00	541.00	542.73		543.00	0.005393	2.29	117.27	102.97	0.68
Tecate	9760	10 year	268.00	539.00	540.89	540.84	541.53	0.009914	3.56	75.37	53.65	0.96
Tecate	9560	10 year	268.00	538.00	539.10	539.10	539.45	0.010053	2.63	101.95	145.78	1.00
Tecate	9360	10 year	268.00	536.00	538.19		538.29	0.001460	1.43	187.71	157.72	0.42
Tecate	9160	10 year	268.00	536.00	537.81		537.96	0.001896	1.71	156.46	96.38	0.43
Tecate	8960	10 year	268.00	535.00	537.03	536.56	537.38	0.004468	2.63	103.31	123.04	0.66
Tecate	8760	10 year	268.00	534.00	535.44	535.44	535.98	0.011967	3.26	82.15	76.61	1.01
Tecate	8560	10 year	268.00	531.00	533.13		533.43	0.007054	2.43	110.42	63.17	0.59
Tecate	8360	10 year	268.00	529.00	531.29	531.29	531.83	0.008846	3.26	82.12	77.03	1.01
Tecate	8160	10 year	268.00	527.00	529.15	529.06	529.79	0.006696	3.54	75.75	50.95	0.93
Tecate	7960	10 year	268.00	525.00	527.59	527.59	528.34	0.007720	3.85	69.57	45.57	1.00
Tecate	7760	10 year	268.00	524.00	526.16		526.37	0.003173	2.06	129.83	88.98	0.55
Tecate	7560	10 year	268.00	523.00	525.80		525.98	0.001269	1.87	143.16	71.74	0.42
Tecate	7360	10 year	268.00	523.00	525.33		525.63	0.002478	2.39	112.02	64.37	0.58
Tecate	7160	10 year	268.00	522.00	524.59	524.59	524.97	0.004510	3.18	173.43	243.40	0.69
Tecate	6960	10 year	268.00	519.00	522.53	522.53	523.18	0.003746	3.73	101.40	112.98	0.74
Tecate	6760	10 year	268.00	518.00	521.43	521.43	522.09	0.005156	3.76	95.42	99.43	0.74
Tecate	6560	10 year	268.00	516.00	519.55		519.99	0.005125	3.29	147.88	178.24	0.65
Tecate	6360	10 year	268.00	515.00	518.47	518.47	518.86	0.006074	3.09	131.85	167.46	0.62
Tecate	6160	10 year	268.00	514.00	516.64		517.10	0.012581	3.62	131.35	185.52	0.79
Tecate	5960	10 year	268.00	512.00	514.66	514.66	514.96	0.008827	3.20	162.36	234.95	0.73
Tecate	5760	10 year	268.00	511.00	512.99		513.28	0.006804	2.96	152.44	168.29	0.72
Tecate	5560	10 year	268.00	509.00	511.63	511.63	512.21	0.004301	3.65	111.45	117.90	0.78
Tecate	5360	10 year	268.00	507.00	509.50		509.89	0.004897	3.28	150.53	217.83	0.71
Tecate	5160	10 year	268.00	506.00	508.65	508.51	508.86	0.005420	2.54	218.11	287.29	0.53
Tecate	4960	10 year	268.00	505.00	507.38	507.01	507.51	0.008638	2.25	216.68	209.13	0.48
Tecate	4760	10 year	268.00	501.00	504.50		505.00	0.017034	3.33	111.48	129.28	0.67
Tecate	4560	10 year	268.00	500.00	503.04		503.32	0.004688	2.42	133.51	136.76	0.50
Tecate	4360	10 year	268.00	499.00	501.22		501.76	0.014502	3.26	82.24	51.63	0.82
Tecate	4160	10 year	268.00	497.00	500.08		500.29	0.003801	2.81	178.06	186.37	0.62
Tecate	3960	10 year	268.00	496.00	498.93		499.19	0.008218	2.37	136.59	133.92	0.57
Tecate	3760	10 year	268.00	496.00	497.71		497.84	0.005037	2.10	243.69	340.12	0.59
Tecate	3560	10 year	268.00	494.00	496.84		496.98	0.003928	1.89	201.91	187.45	0.44
Tecate	3360	10 year	268.00	493.00	495.29	495.25	495.84	0.009542	3.28	85.82	95.18	0.92
Tecate	3160	10 year	268.00	492.00	494.10	493.76	494.41	0.005068	2.46	118.27	181.79	0.68
Tecate	2960	10 year	268.00	491.00	492.37		492.61	0.019767	2.21	132.40	159.45	0.66
Tecate	2760	10 year	268.00	489.00	491.75		491.82	0.001502	1.22	220.12	155.55	0.33
Tecate	2560	10 year	268.00	488.00	491.01	490.49	491.28	0.005636	2.28	117.65	87.01	0.63
Tecate	2360	10 year	268.00	488.00	489.38	489.38	489.80	0.009740	2.95	107.24	170.88	0.91
Tecate	2160	10 year	268.00	486.00	488.32		488.52	0.003031	2.20	170.96	122.60	0.49
Tecate	1960	10 year	268.00	486.00	486.99	486.99	487.39	0.013047	2.82	95.08	118.41	1.00
Tecate	1760	10 year	268.00	483.00	486.10		486.27	0.002639	1.84	145.89	88.17	0.45
Tecate	1560	10 year	268.00	482.00	485.00	484.25	485.44	0.006967	2.94	91.61	121.04	0.60
Tecate	1360	10 year	268.00	480.00	482.79	482.79	483.72	0.010146	4.29	62.41	33.38	1.00
Tecate	1160	10 year	268.00	479.00	481.63	481.27	482.05	0.005282	2.87	93.31	56.88	0.72
Tecate	0960	10 year	268.00	478.00	480.02	480.01	480.52	0.011959	3.12	85.83	85.52	0.99
Tecate	0760	10 year	268.00	477.00	479.05		479.26	0.003451	2.04	131.62	98.39	0.56
Tecate	0560	10 year	268.00	476.00	477.92		478.37	0.005682	2.96	90.46	55.66	0.74
Tecate	0360	10 year	268.00	474.00	476.18	476.18	476.76	0.011999	3.37	79.55	70.93	1.02
Tecate	01[illegible]	10 year	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.56
Tecate	0000	10 year	268.00	472.00	474.11	473.82	474.51	0.005751	2.78	96.36	65.50	0.73

Figure 81. HEC-RAS summary table, 10-yr frequency

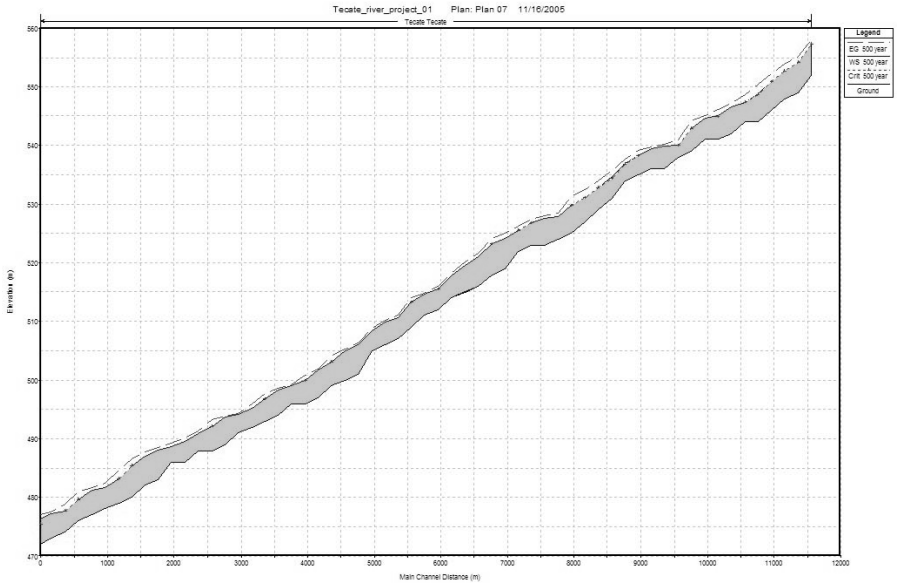

Figure 82. HEC-RAS water-surface profile, 500-yr frequency

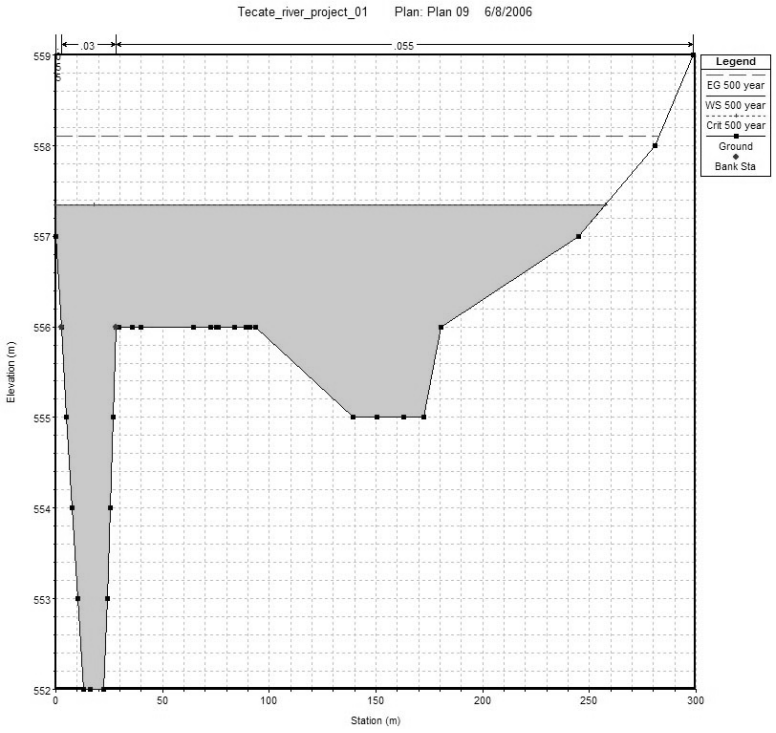

Figure 83. Calculated cross section at RM 11+560, 500-yr frequency

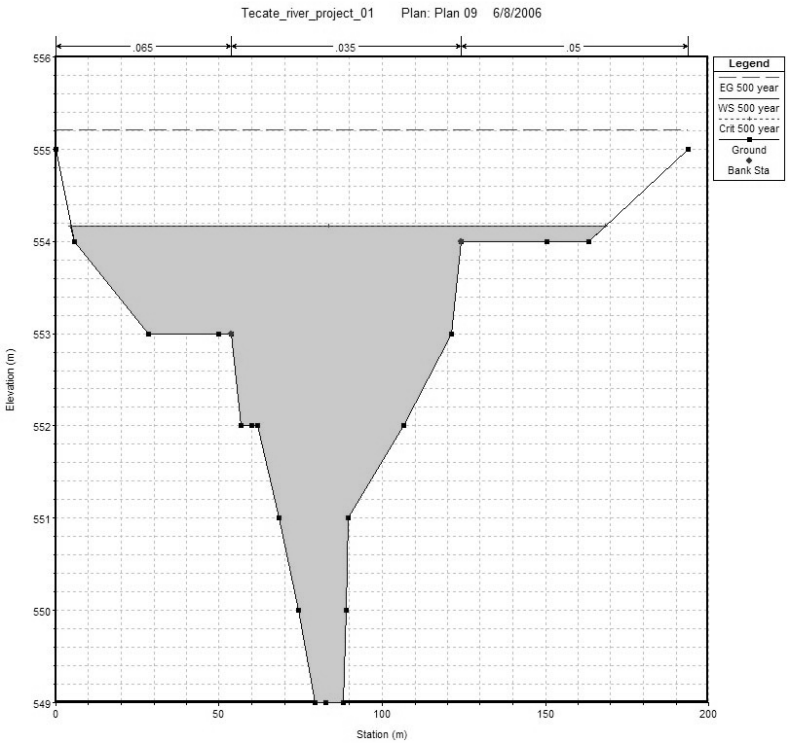

Figure 84. Calculated cross section at RM 11+360, 500-yr frequency

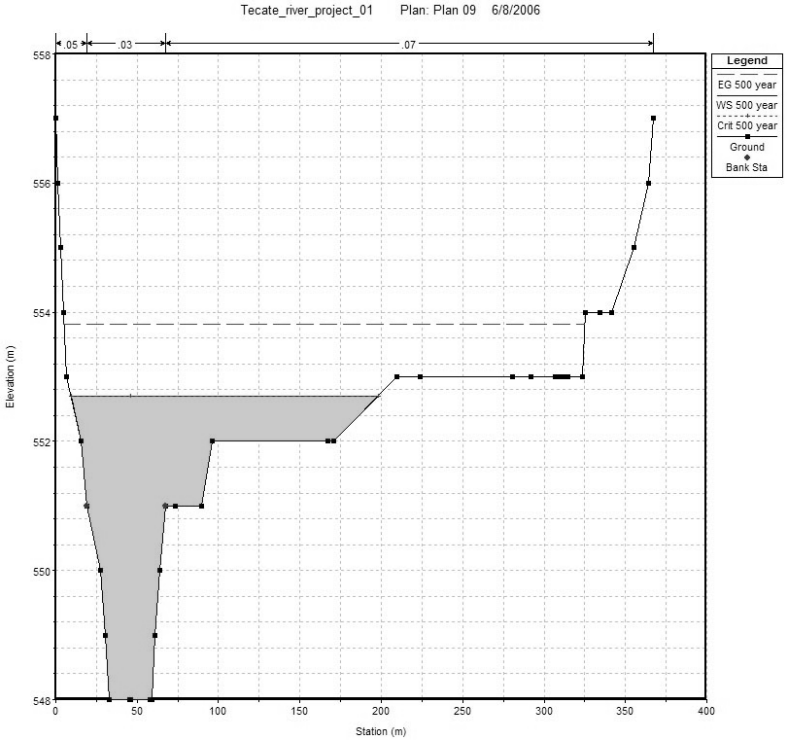

Figure 85. Calculated cross section at RM 11+160, 500-yr frequency

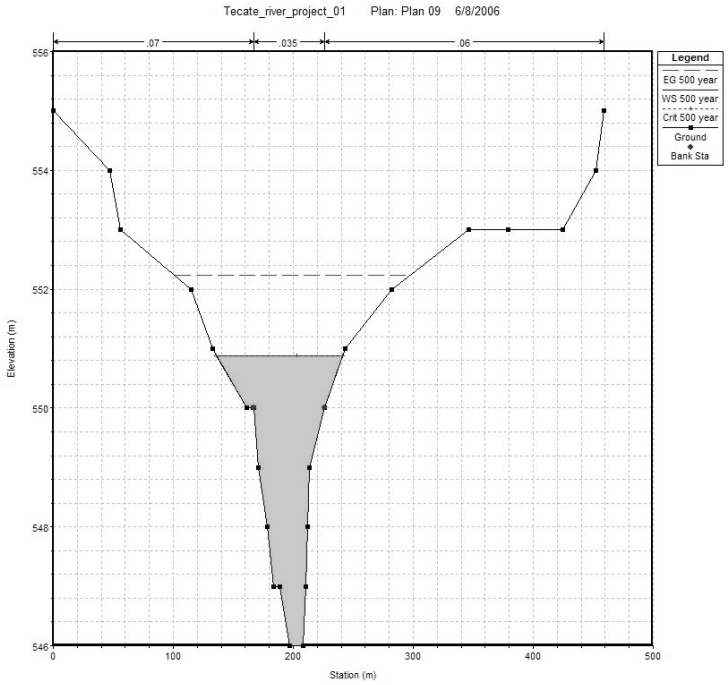

Figure 86. Calculated cross section at RM 10+960, 500-yr frequency

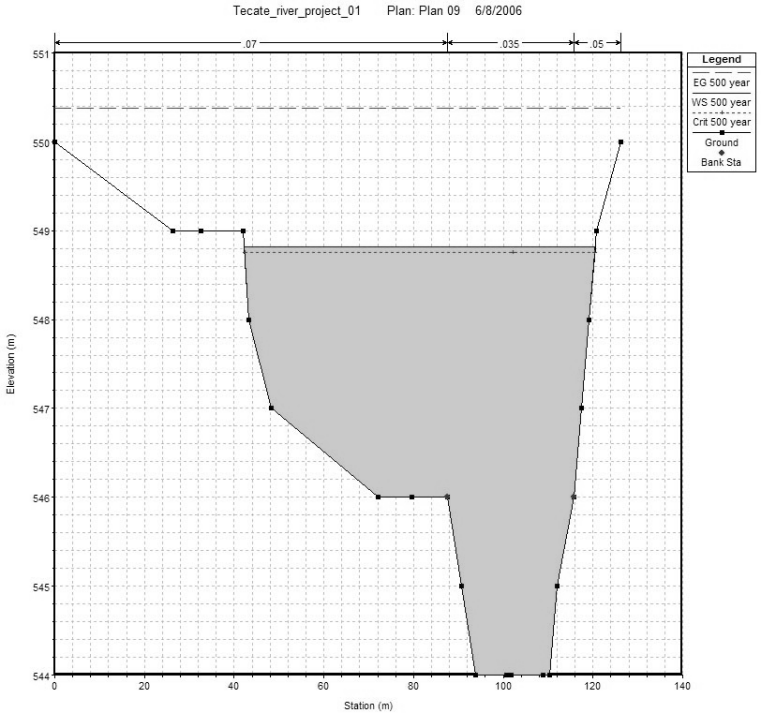

Figure 87. Calculated cross section at RM 10+760, 500-yr frequency

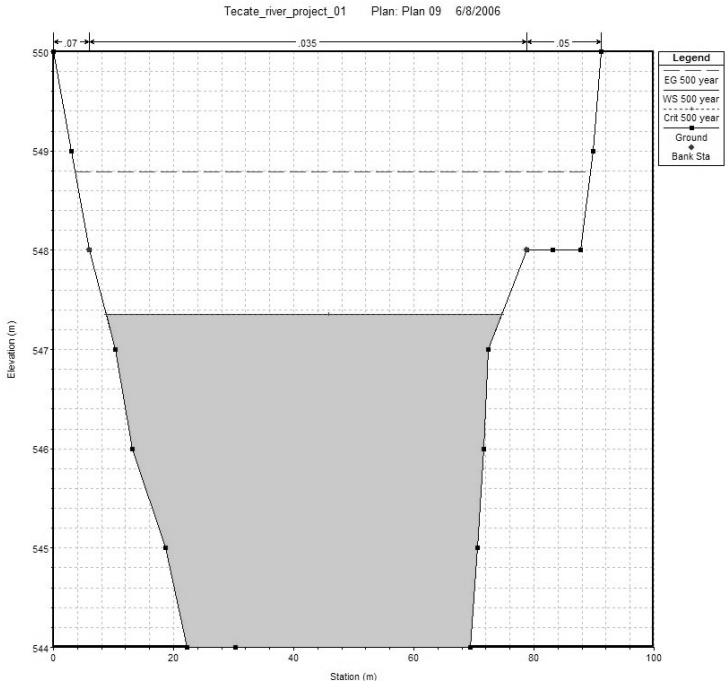

Figure 88. Calculated cross section at RM 10+560, 500-yr frequency

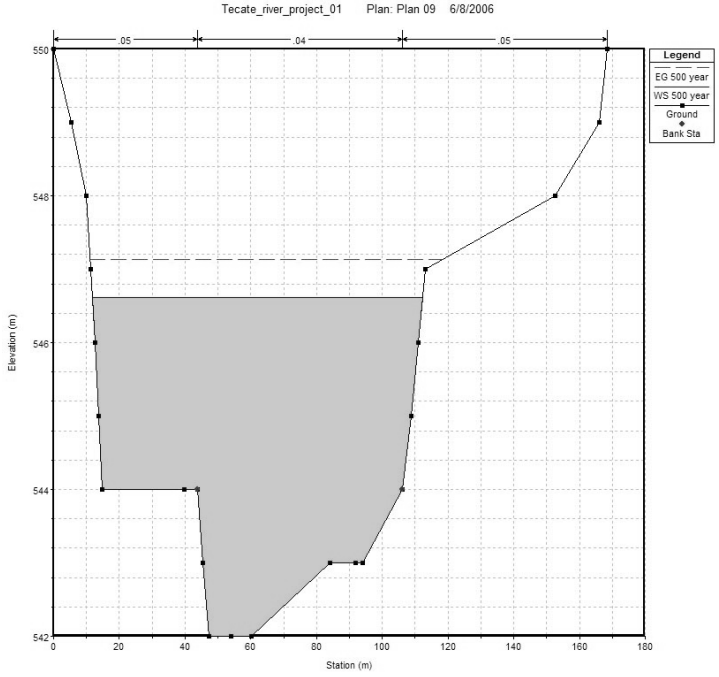

Figure 89. Calculated cross section at RM 10+360, 500-yr frequency

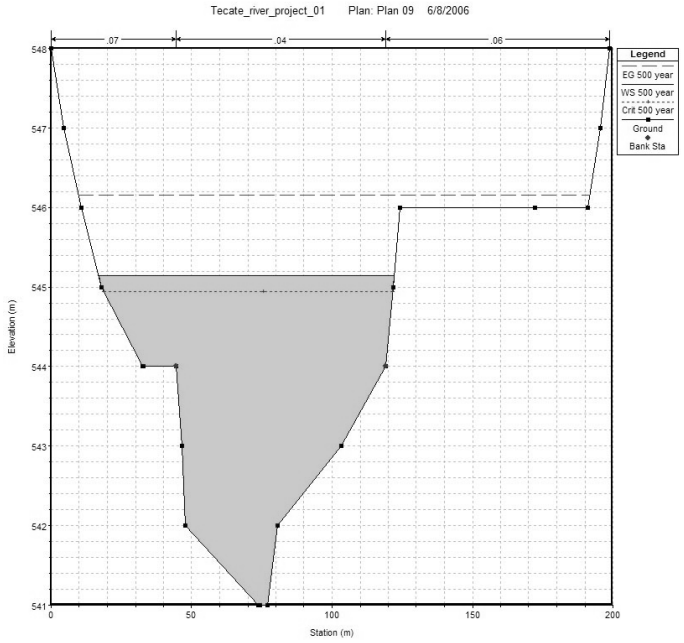

Figure 90. Calculated cross section at RM 10+160, 500-yr frequency

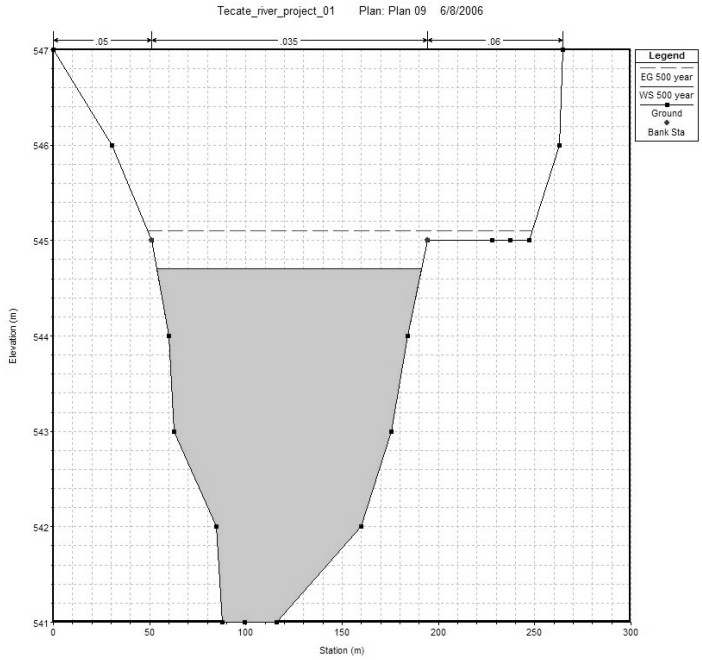

Figure 91. Calculated cross section at RM 9+960, 500-yr frequency

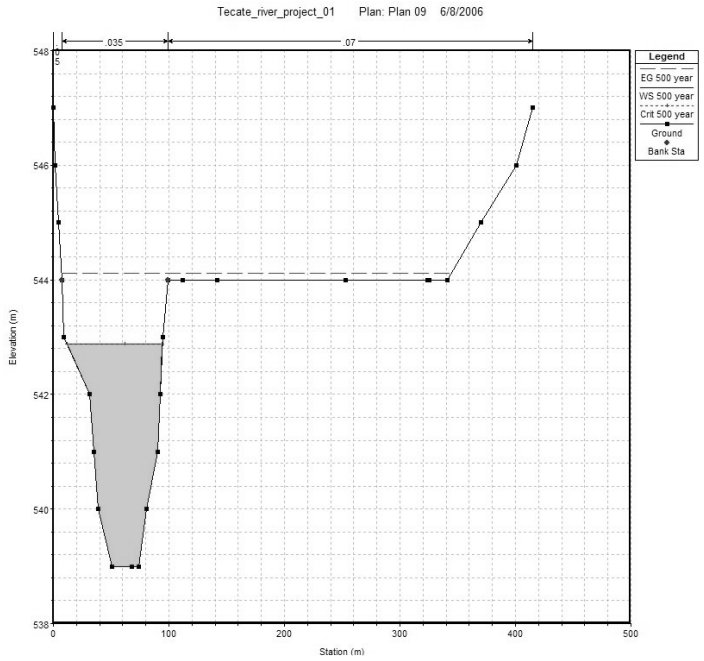

Figure 92. Calculated cross section at RM 9+760, 500-yr frequency

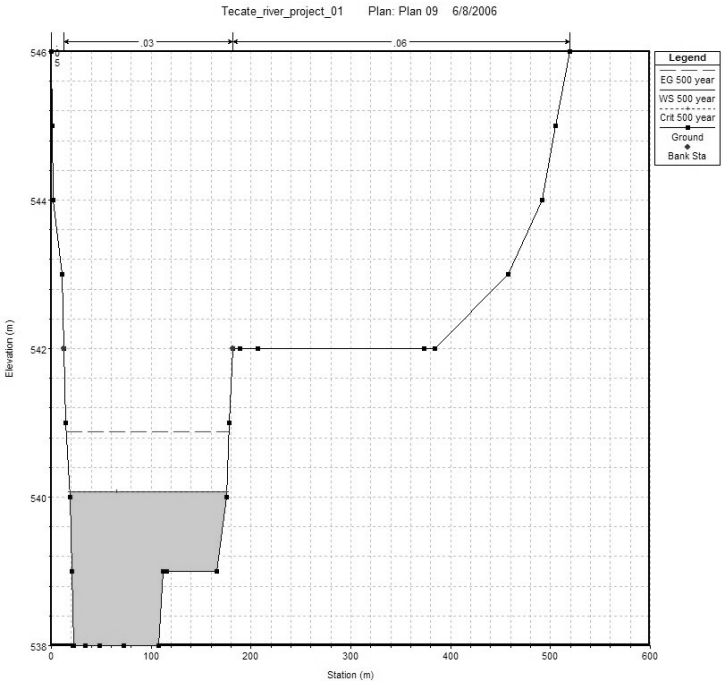

Figure 93. Calculated cross section at RM 9+560, 500-yr frequency

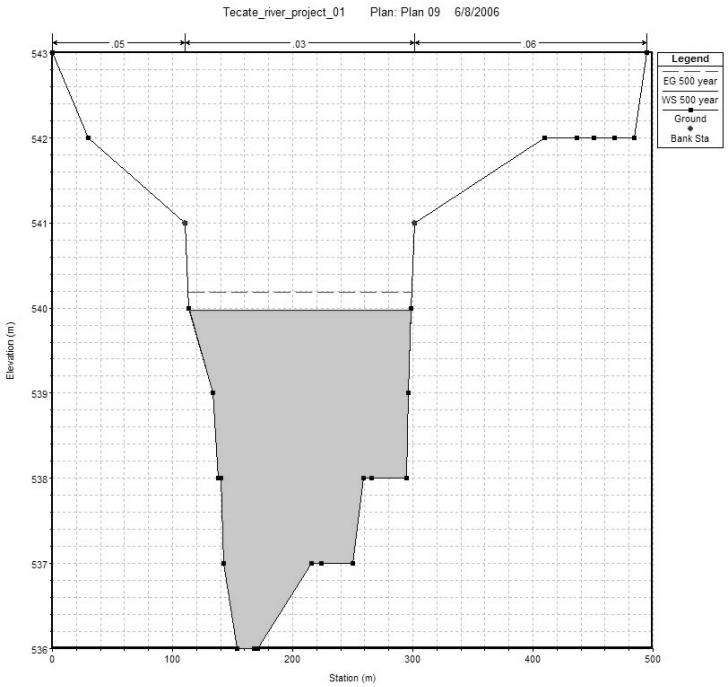

Figure 94. Calculated cross section at RM 9+360, 500-yr frequency

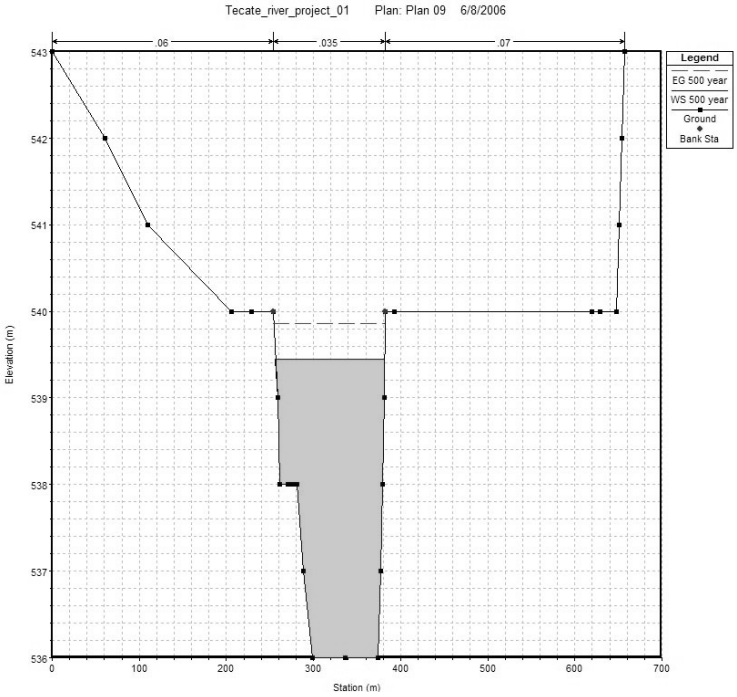

Figure 95. Calculated cross section at RM 9+160, 500-yr frequency

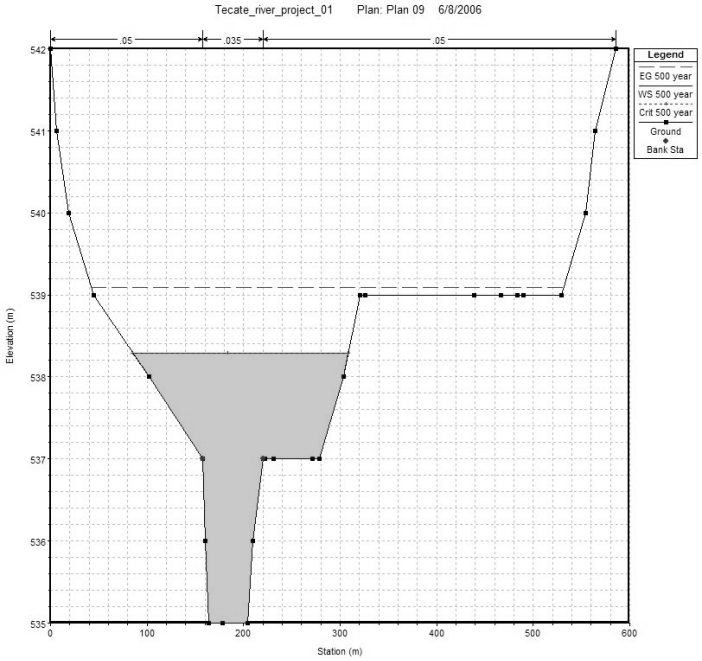

Figure 96. Calculated cross section at RM 8+960, 500-yr frequency

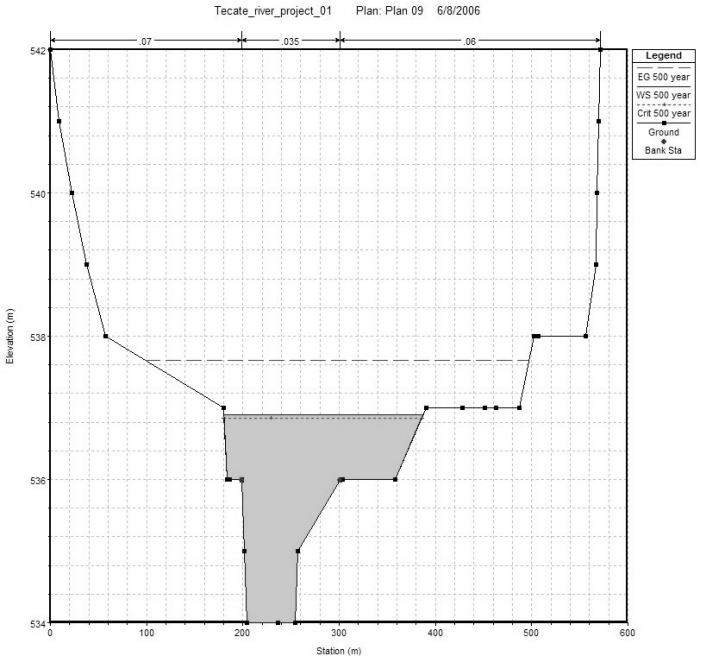

Figure 97. Calculated cross section at RM 8+760, 500-yr frequency

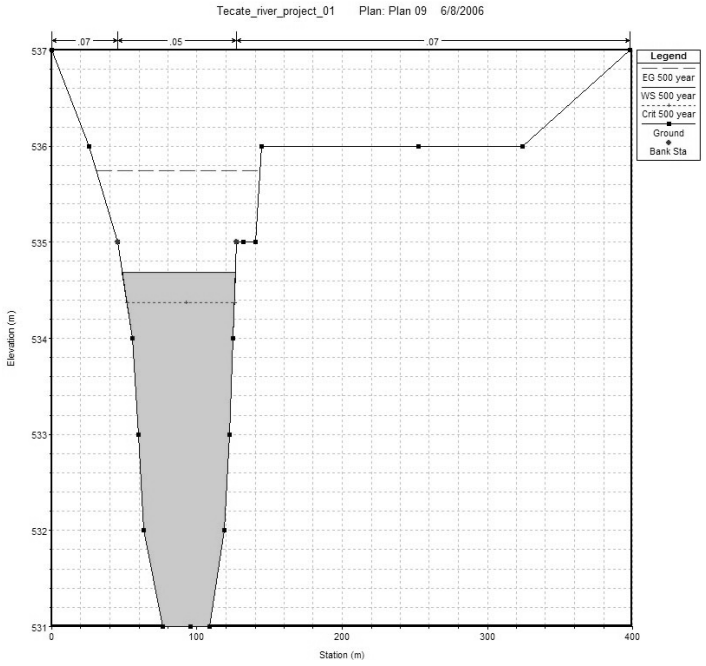

Figure 98. Calculated cross section at RM 8+560, 500-yr frequency

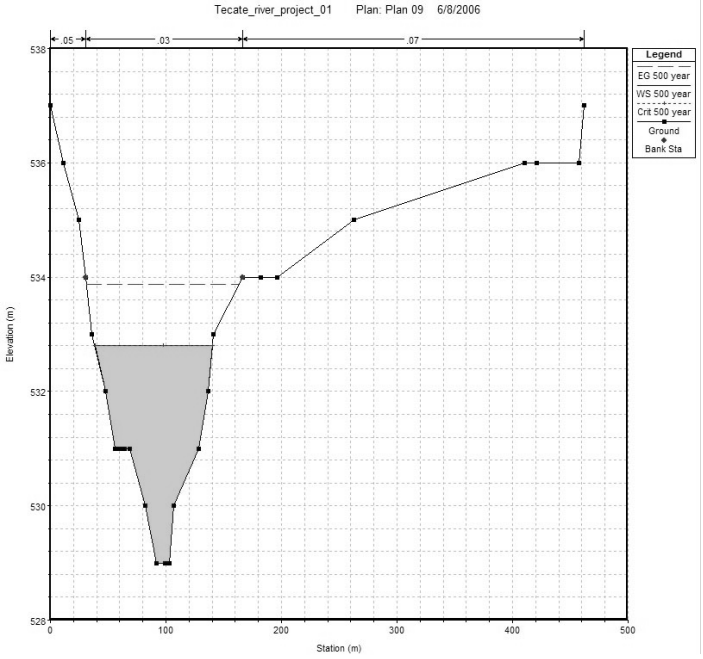

Figure 99. Calculated cross section at RM 8+360, 500-yr frequency

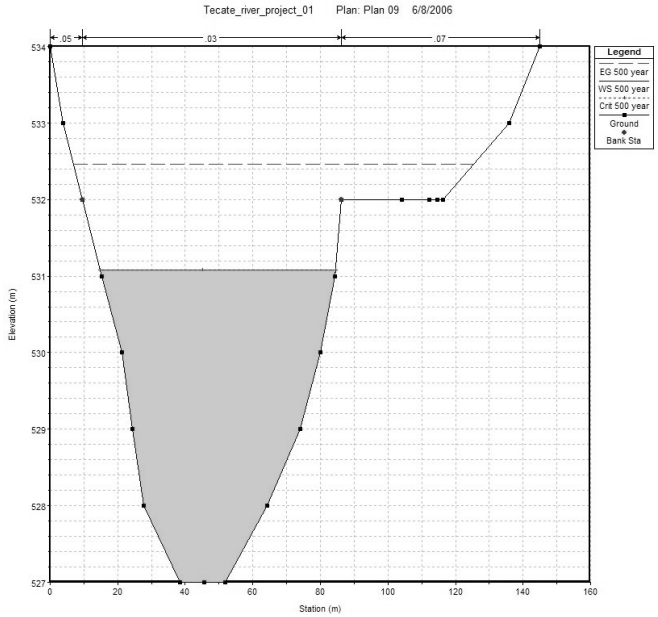

Figure 100. Calculated cross section at RM 8+160, 500-yr frequency

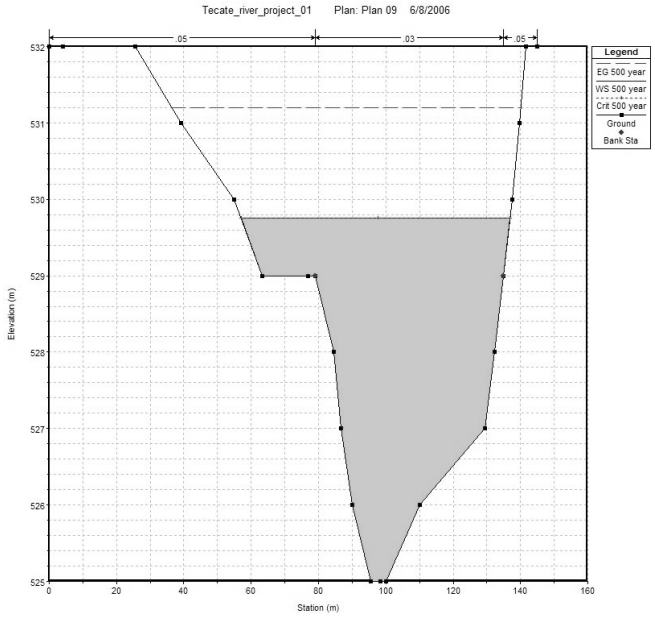

Figure 101. Calculated cross section at RM 7+960, 500-yr frequency

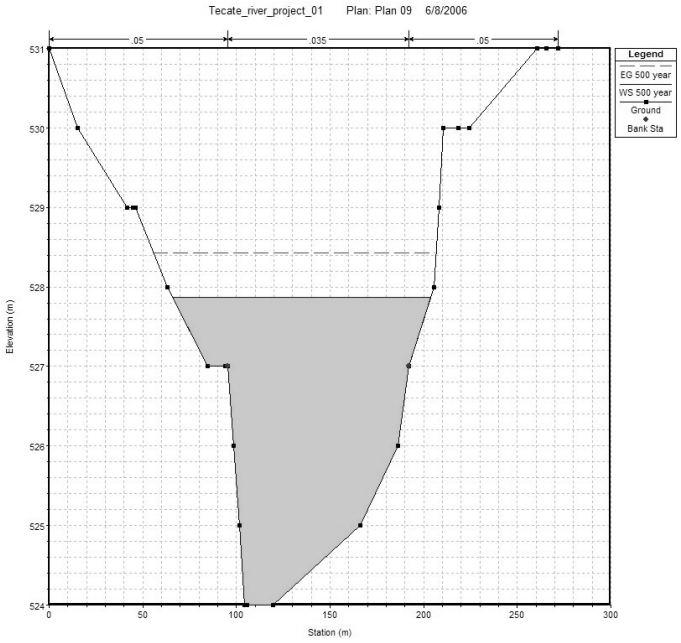

Figure 102. Calculated cross section at RM 7+760, 500-yr frequency

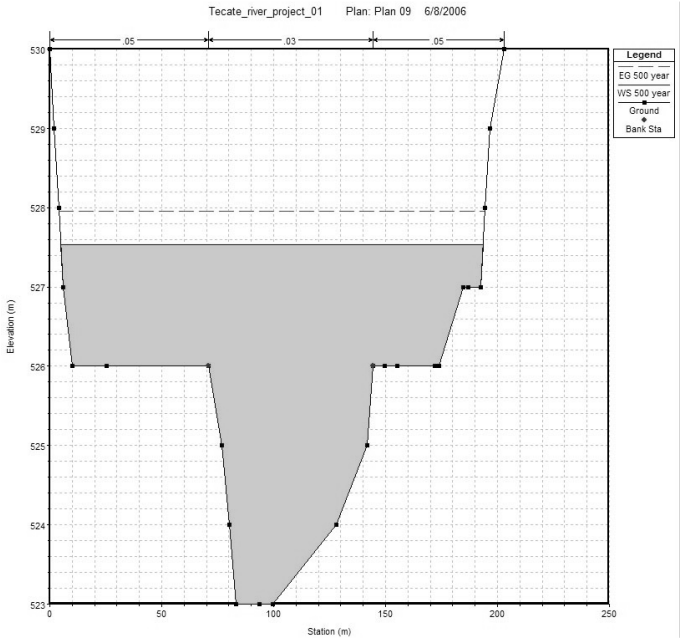

Figure 103. Calculated cross section at RM 7+560, 500-yr frequency

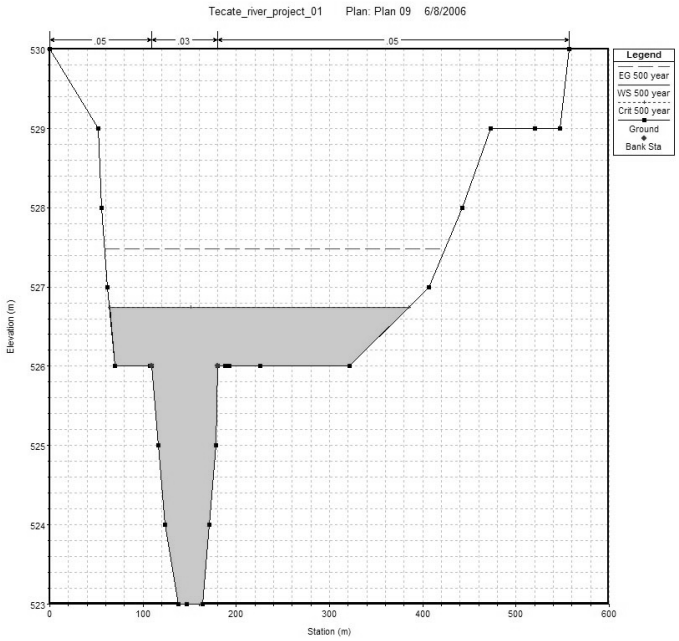

Figure 104. Calculated cross section at RM 7+360, 500-yr frequency

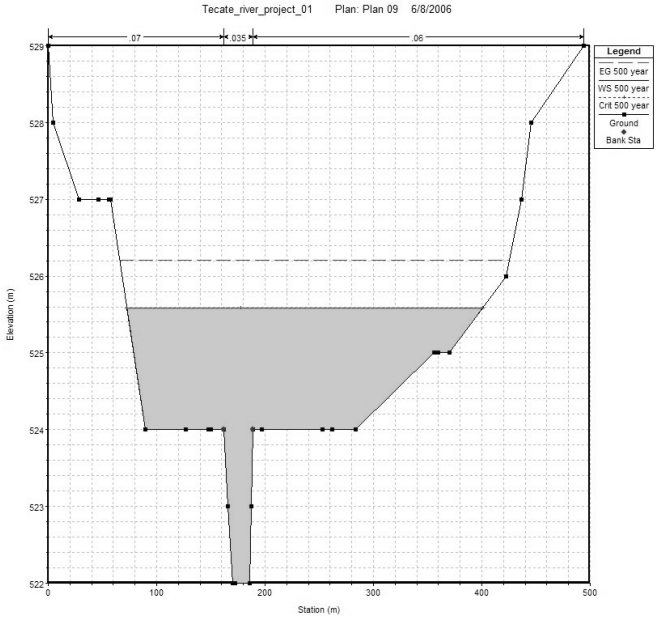

Figure 105. Calculated cross section at RM 7+160, 500-yr frequency

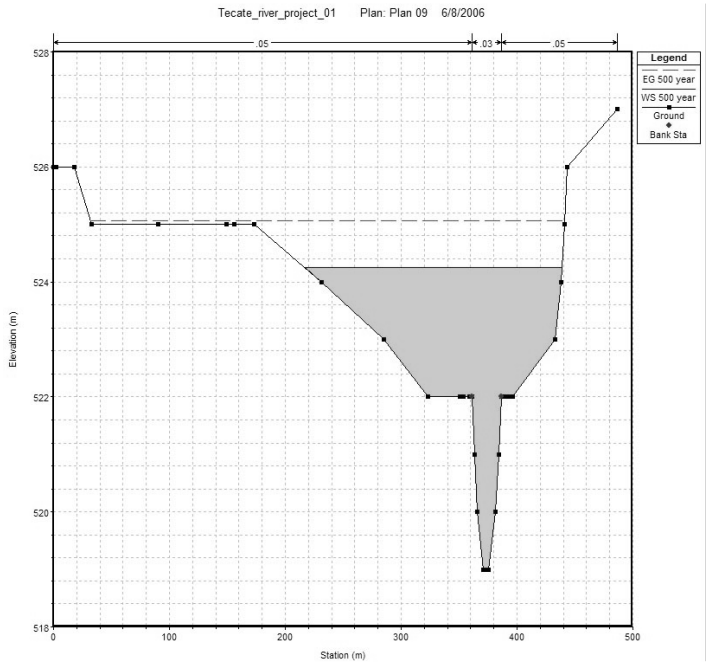

Figure 106. Calculated cross section at RM 6+960, 500-yr frequency

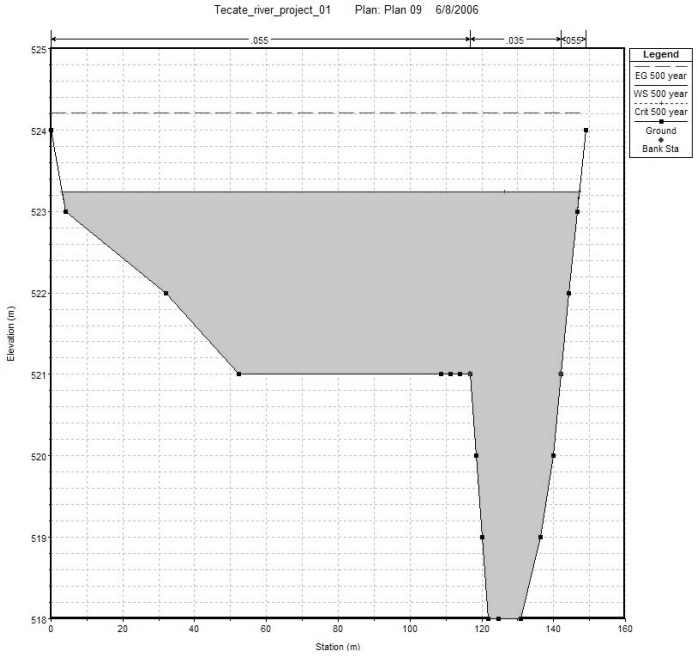

Figure 107. Calculated cross section at RM 6+760, 500-yr frequency

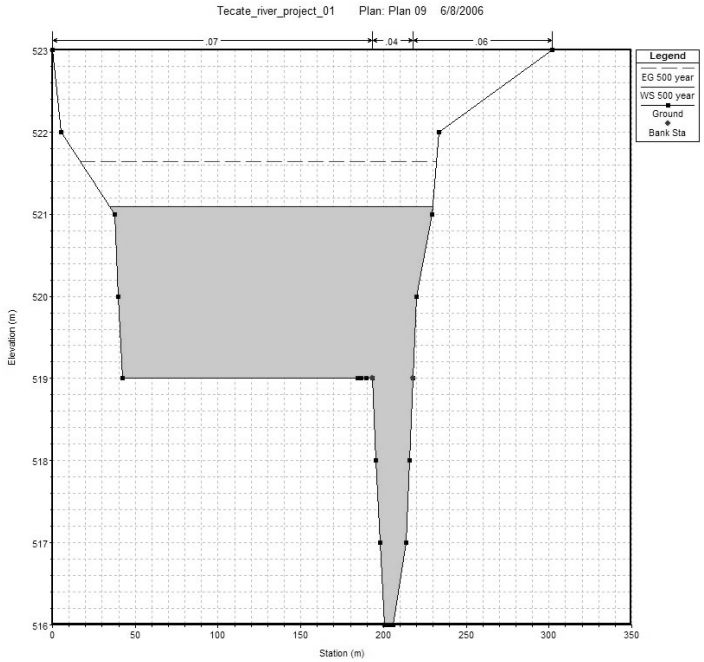

Figure 108. Calculated cross section at RM 6+560, 500-yr frequency

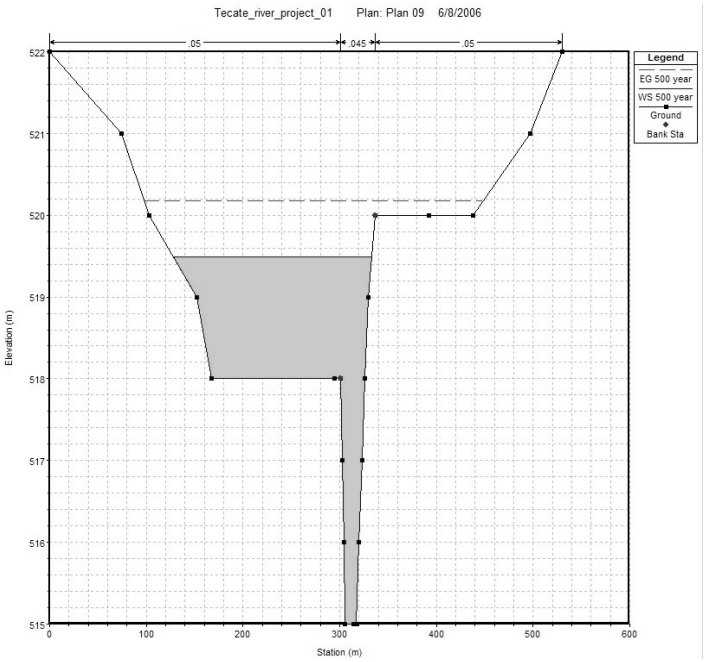

Figure 109. Calculated cross section at RM 6+360, 500-yr frequency

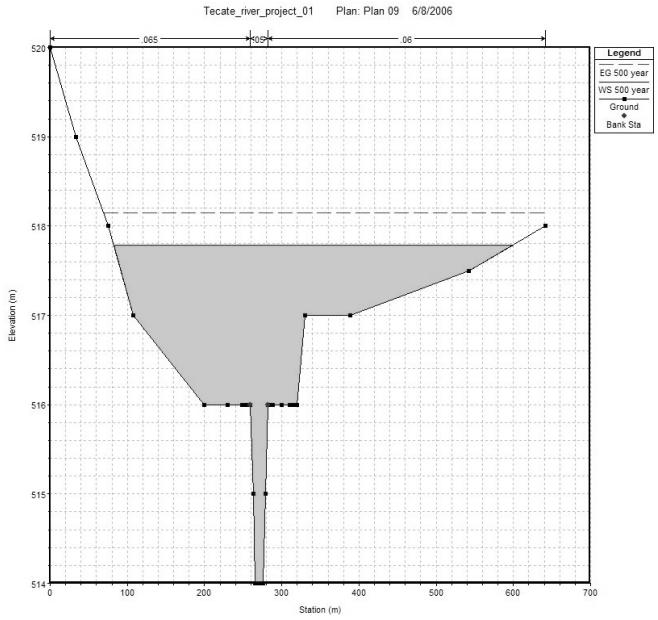

Figure 110. Calculated cross section at RM 6+160, 500-yr frequency

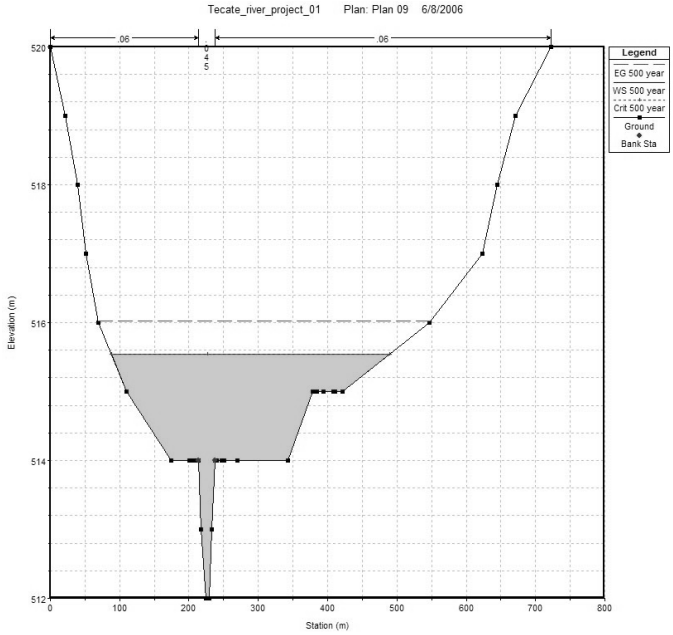

Figure 111. Calculated cross section at RM 5+960, 500-yr frequency

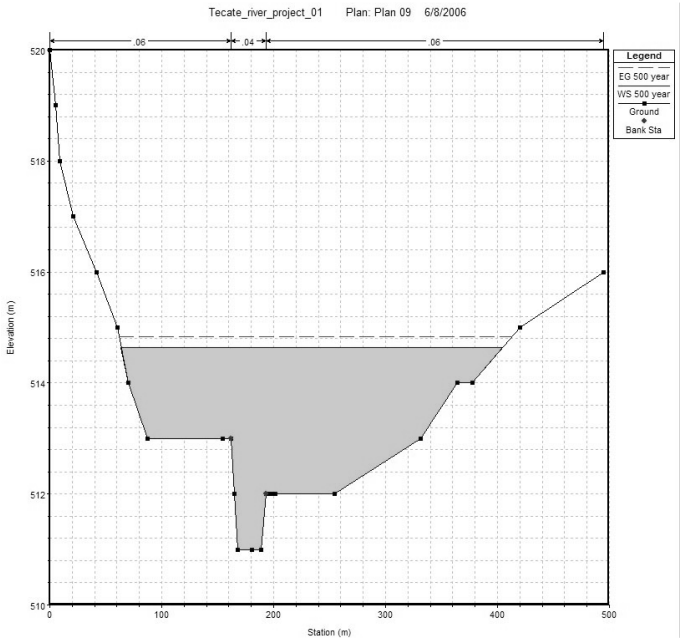

Figure 112. Calculated cross section at RM 5+760, 500-yr frequency

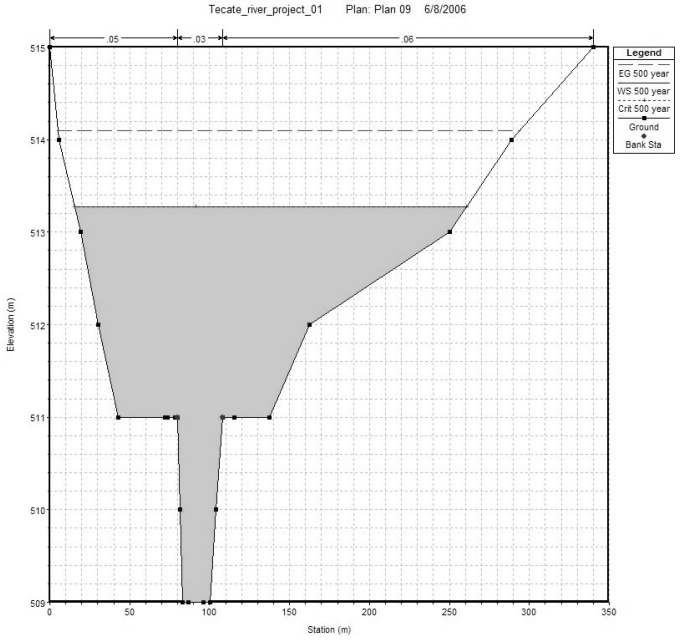

Figure 113. Calculated cross section at RM 5+560, 500-yr frequency

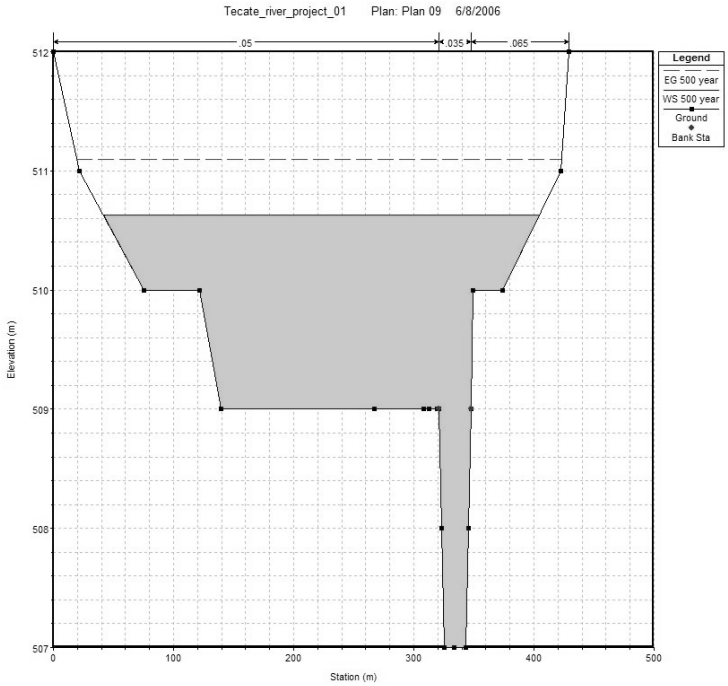

Figure 114. Calculated cross section at RM 5+360, 500-yr frequency

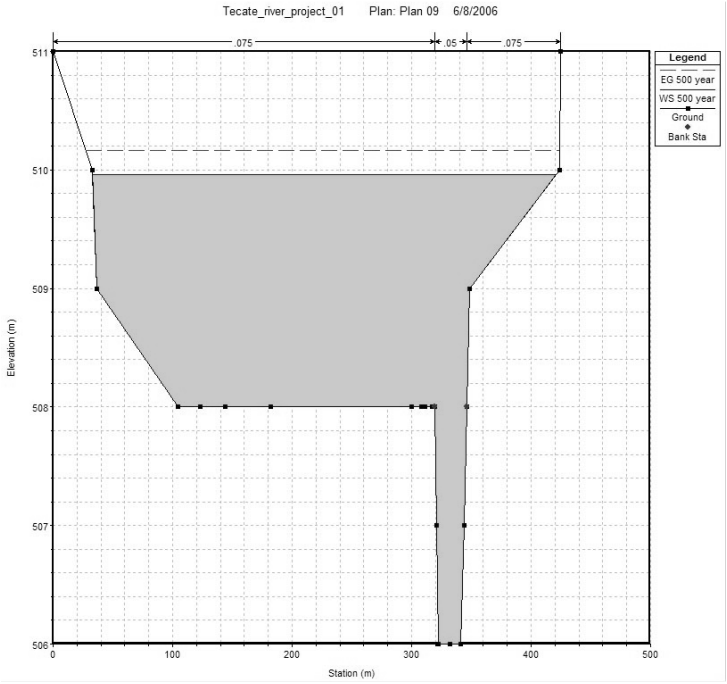

Figure 115. Calculated cross section at RM 5+160, 500-yr frequency

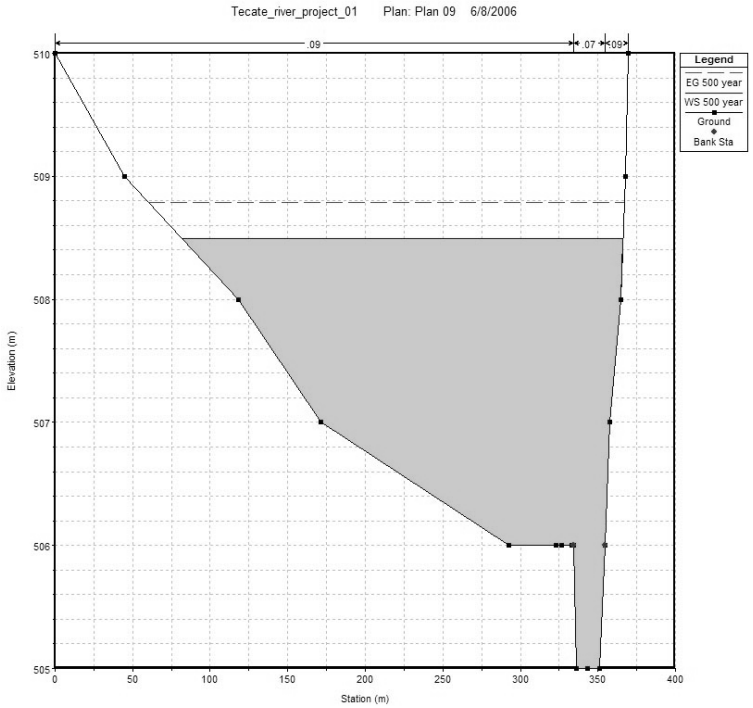

Figure 116. Calculated cross section at RM 4+960, 500-yr frequency

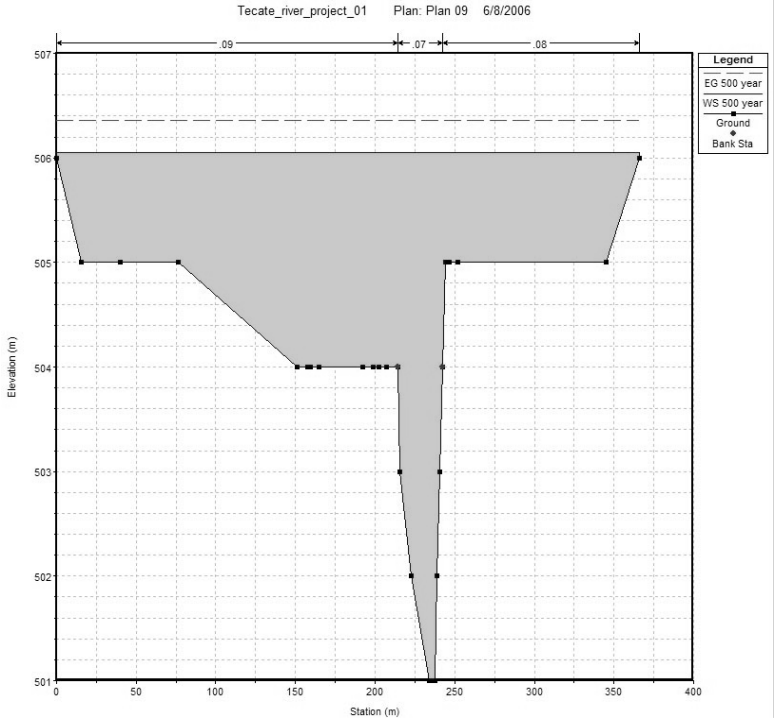

Figure 117. Calculated cross section at RM 4+760, 500-yr frequency

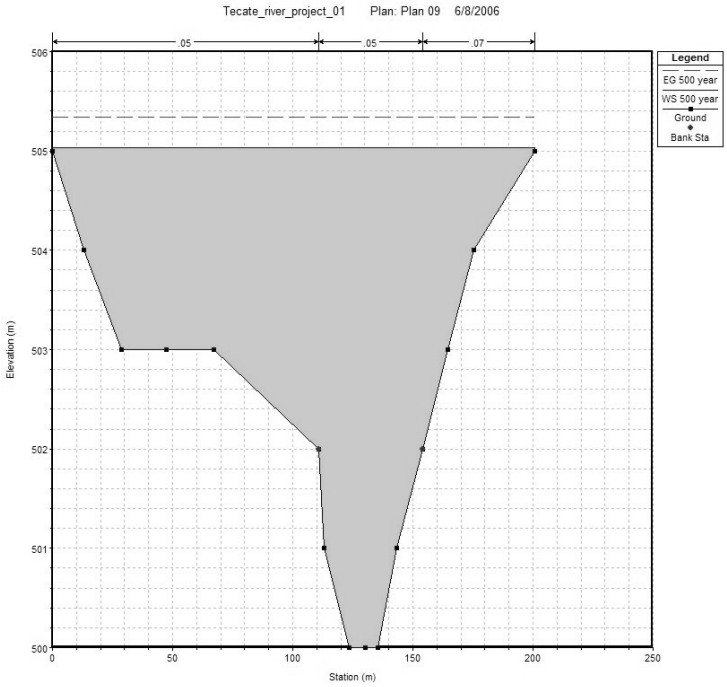

Figure 118. Calculated cross section at RM 4+560, 500-yr frequency

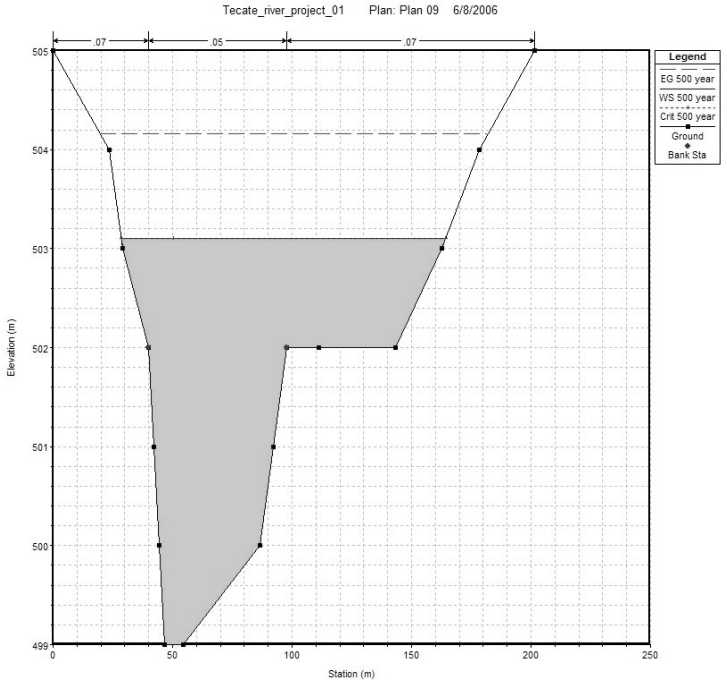

Figure 119. Calculated cross section at RM 4+360, 500-yr frequency

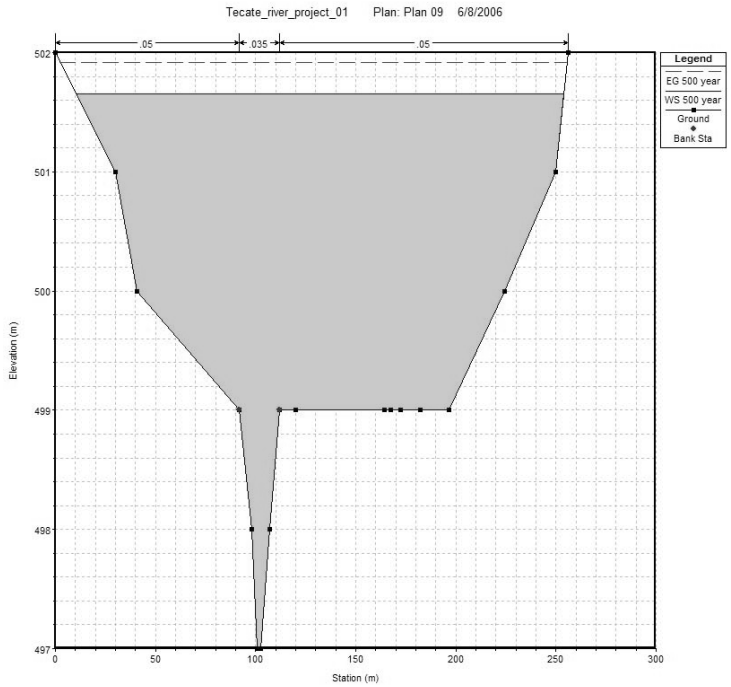

Figure 120. Calculated cross section at RM 4+160, 500-yr frequency

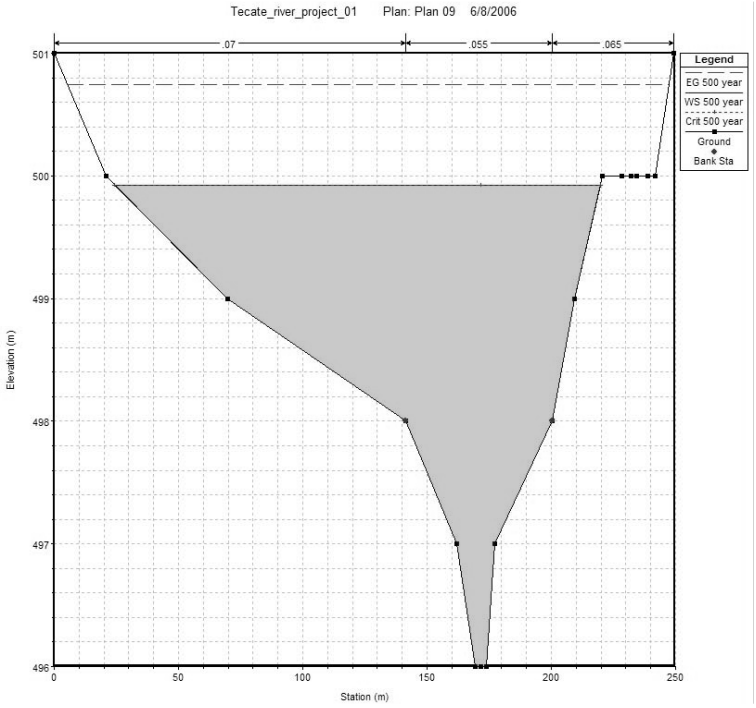

Figure 121. Calculated cross section at RM 3+960, 500-yr frequency

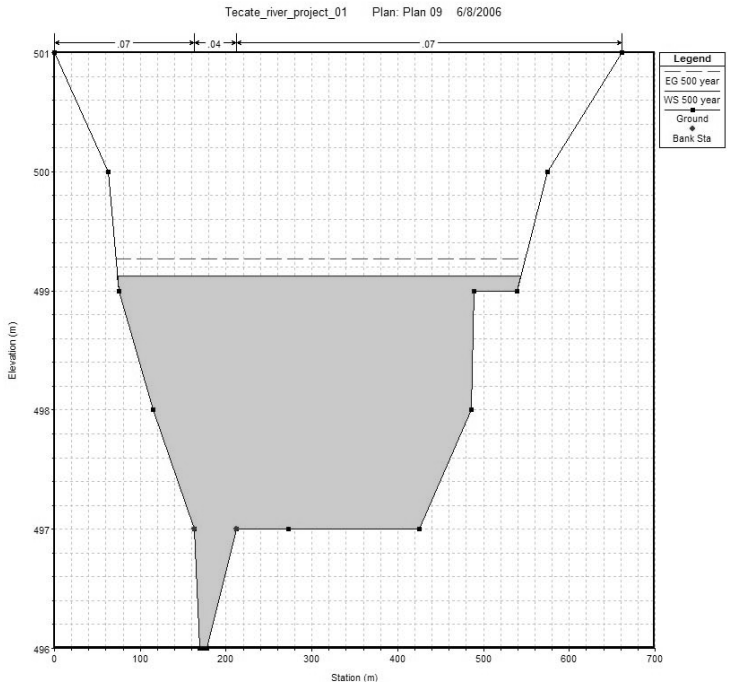

Figure 122. Calculated cross section at RM 3+760, 500-yr frequency

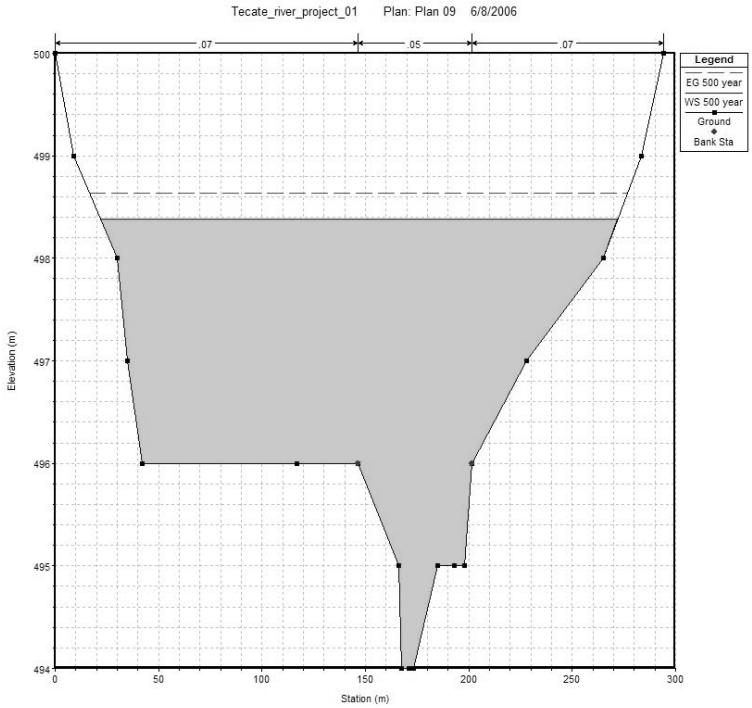

Figure 123. Calculated cross section at RM 3+560, 500-yr frequency

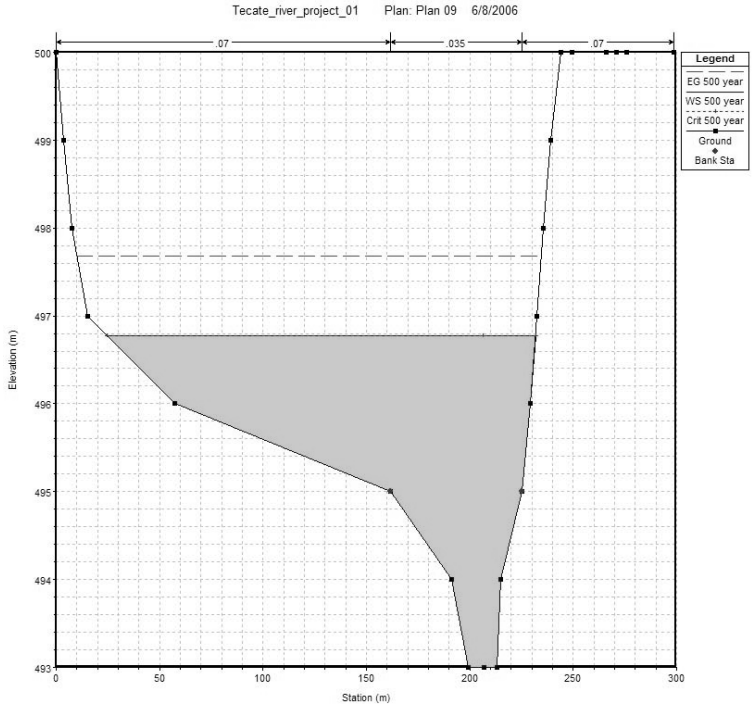

Figure 124. Calculated cross section at RM 3+360, 500-yr frequency

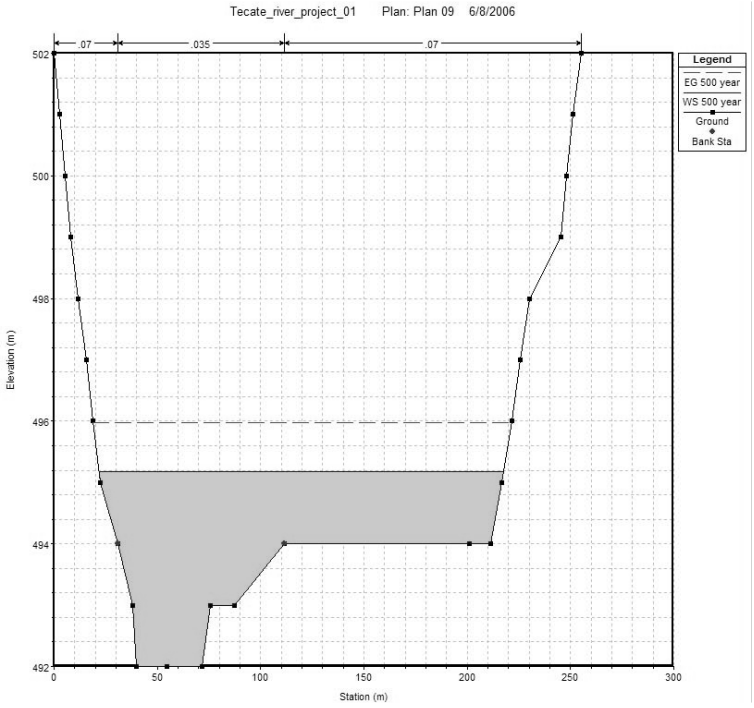

Figure 125. Calculated cross section at RM 3+160, 500-yr frequency

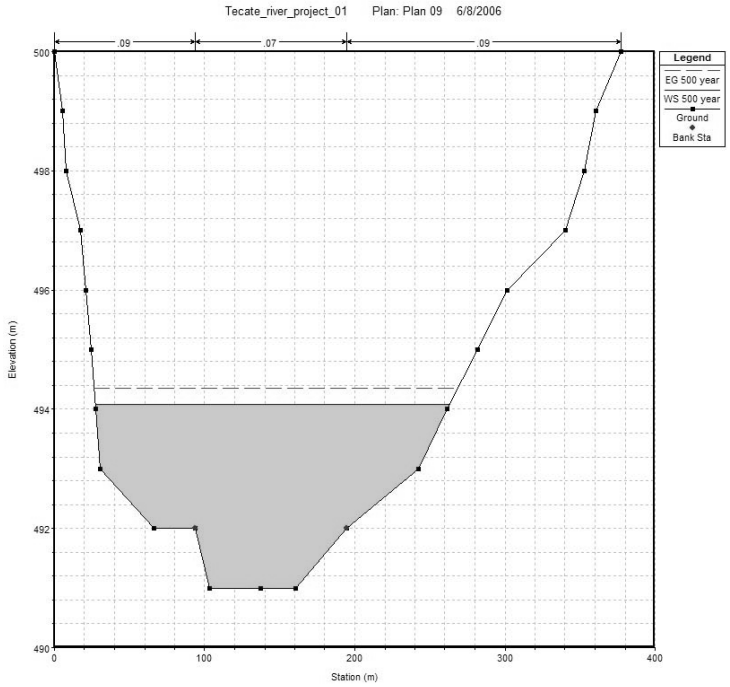

Figure 126. Calculated cross section at RM 2+960, 500-yr frequency

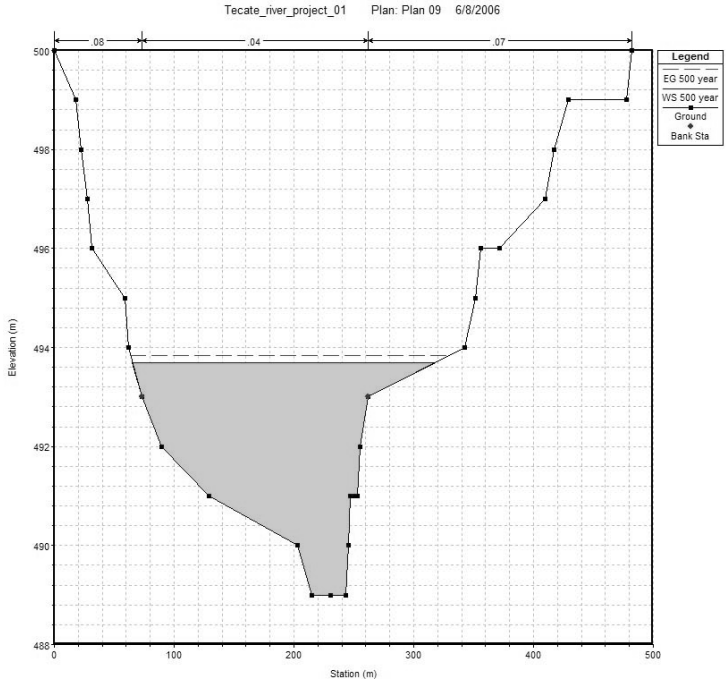

Figure 127. Calculated cross section at RM 2+760, 500-yr frequency

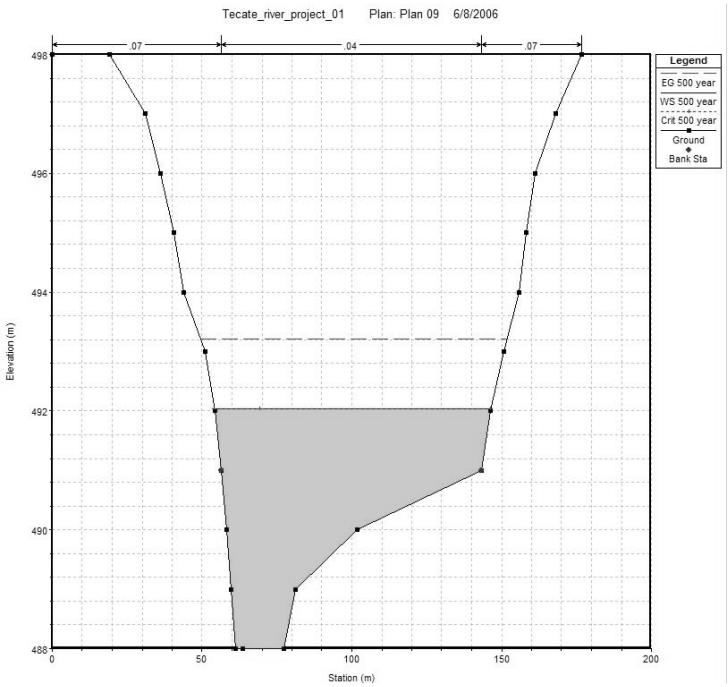

Figure 128. Calculated cross section at RM 2+560, 500-yr frequency

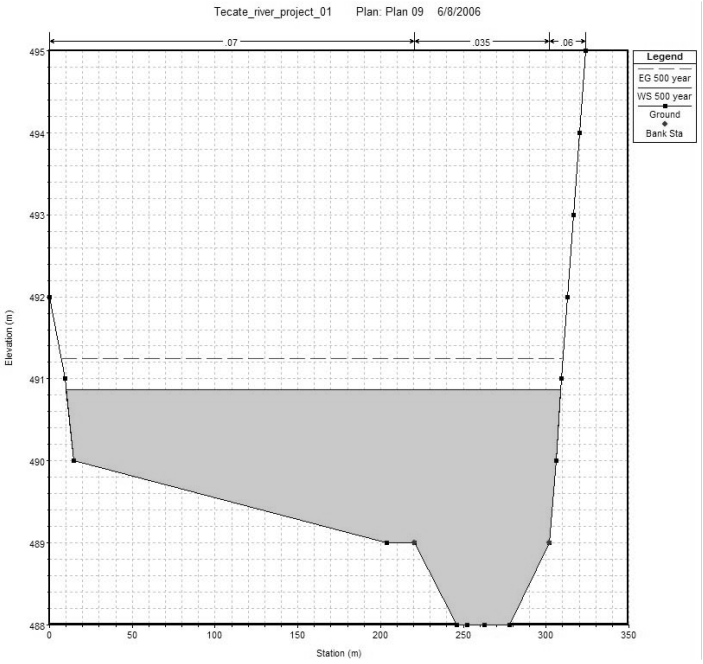

Figure 129. Calculated cross section at RM 2+360, 500-yr frequency

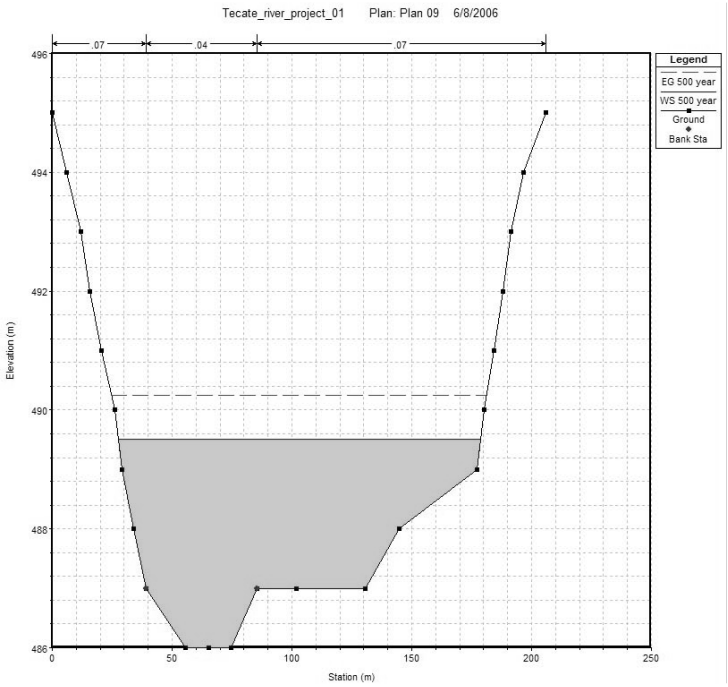

Figure 130. Calculated cross section at RM 2+160, 500-yr frequency

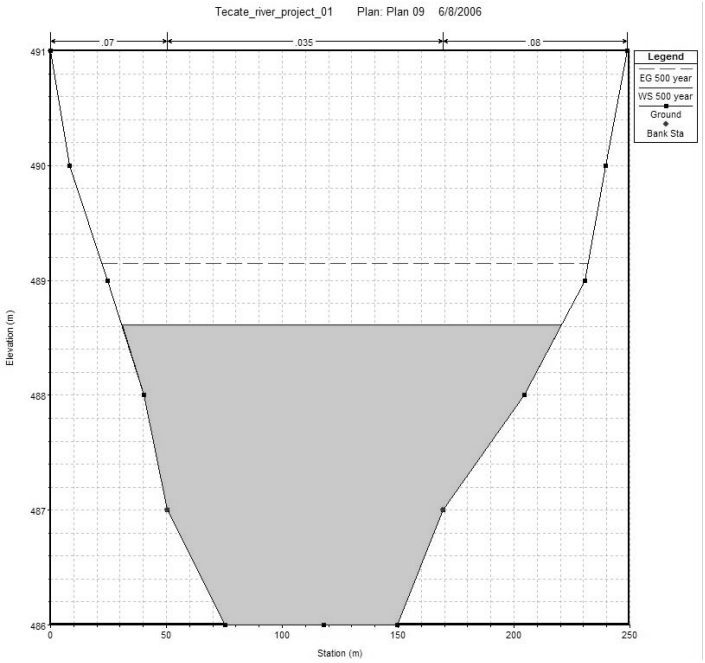

Figure 131. Calculated cross section at RM 1+960, 500-yr frequency

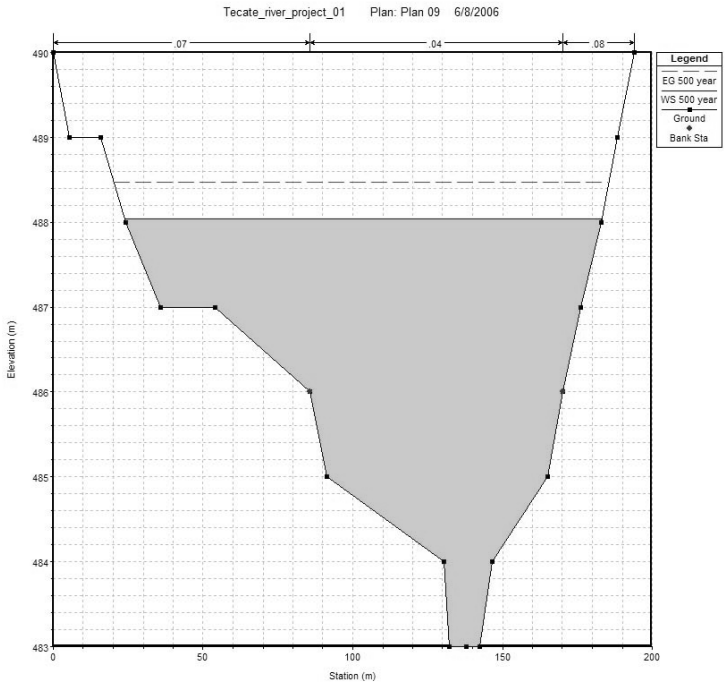

Figure 132. Calculated cross section at RM 1+760, 500-yr frequency

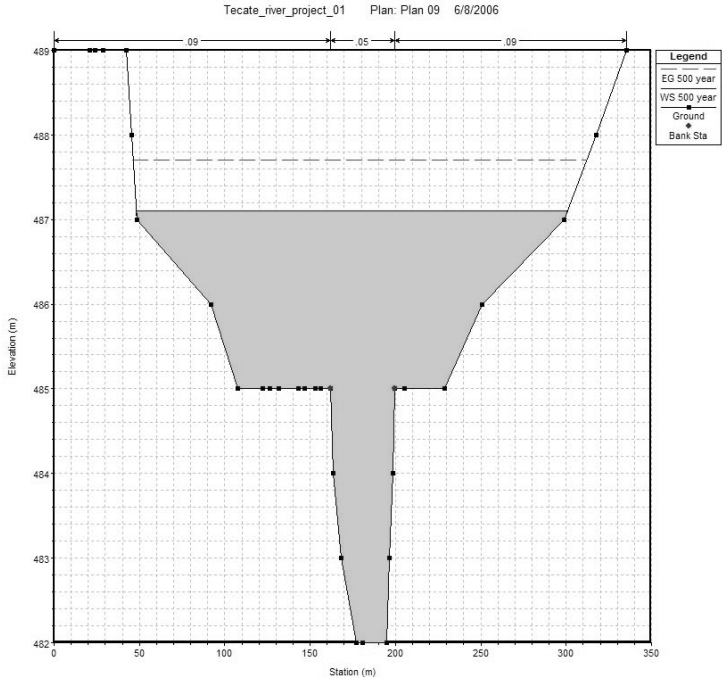

Figure 133. Calculated cross section at RM 1+560, 500-yr frequency

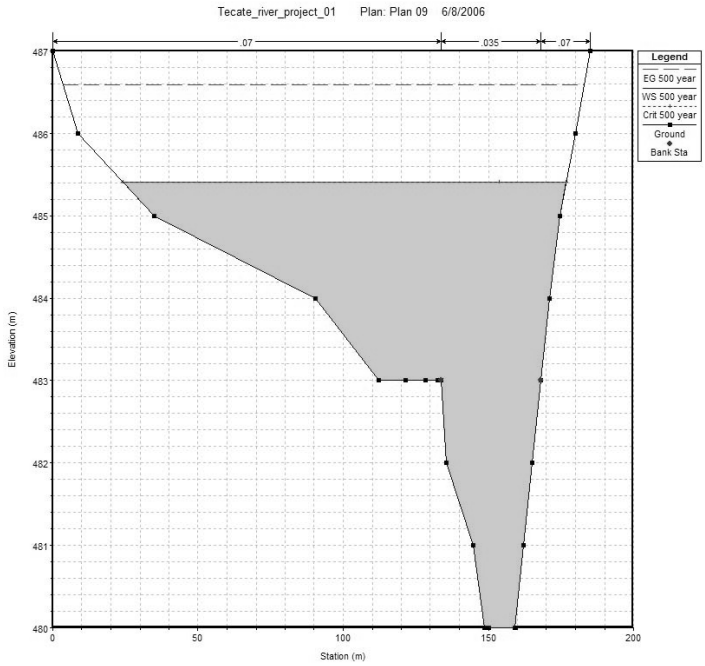

Figure 134. Calculated cross section at RM 1+360, 500-yr frequency

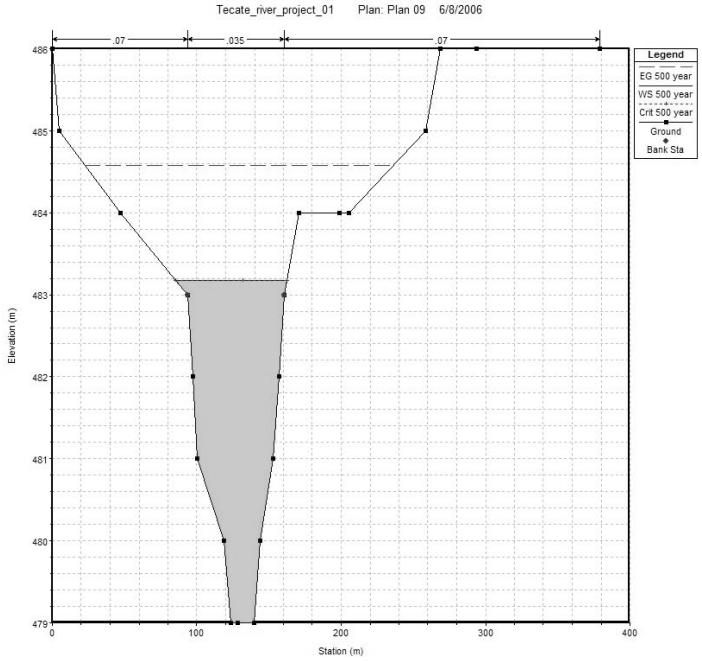

Figure 135. Calculated cross section at RM 1+160, 500-yr frequency

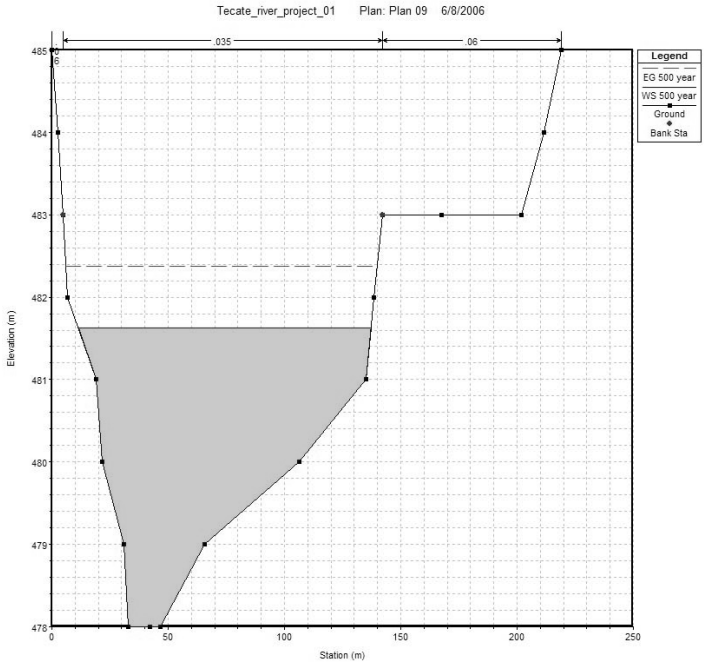

Figure 136. Calculated cross section at RM 0+960, 500-yr frequency

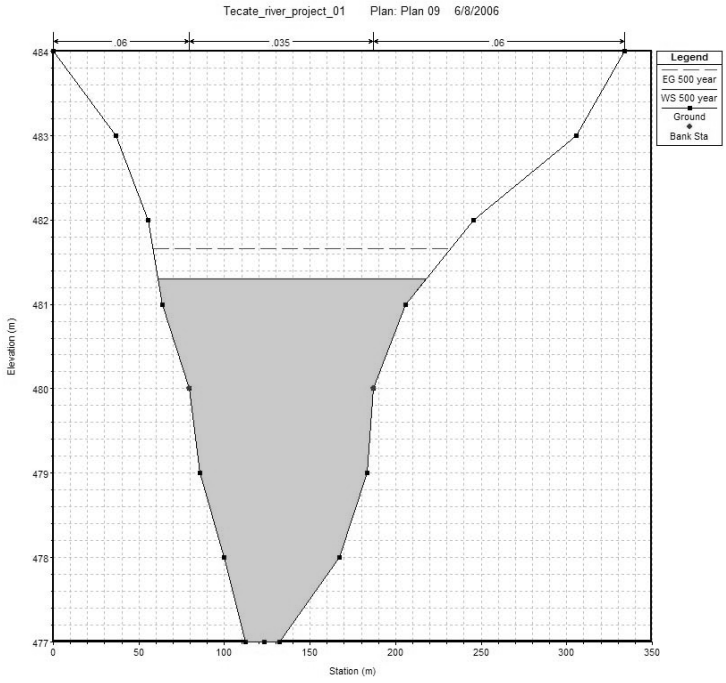

Figure 137. Calculated cross section at RM 0+760, 500-yr frequency

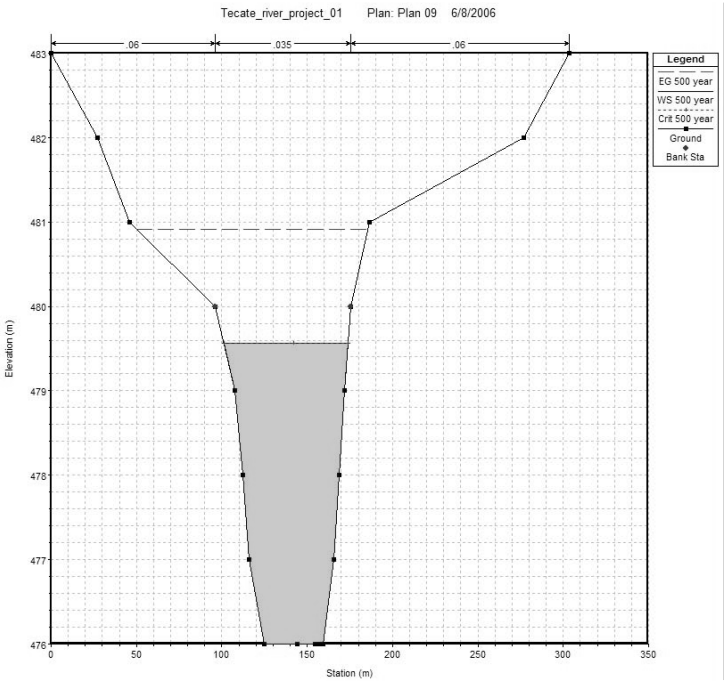

Figure 138. Calculated cross section at RM 0+560, 500-yr frequency

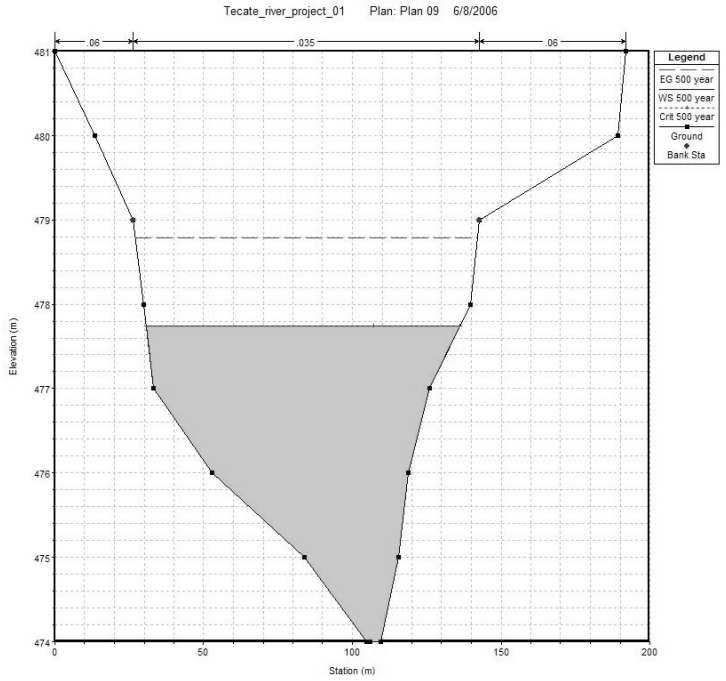

Figure 139. Calculated cross section at RM 0+360, 500-yr frequency

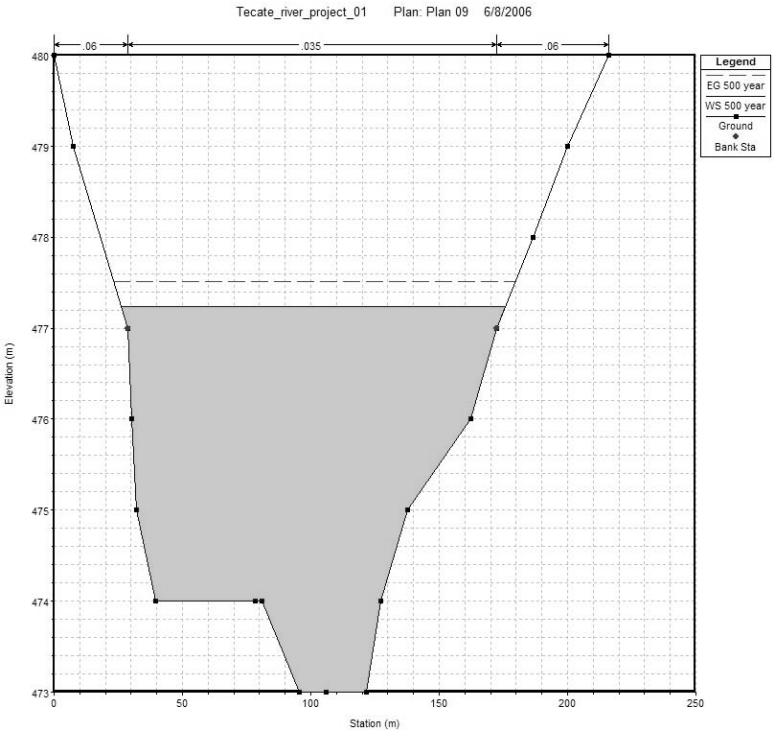

Figure 140. Calculated cross section at RM 0+160, 500-yr frequency

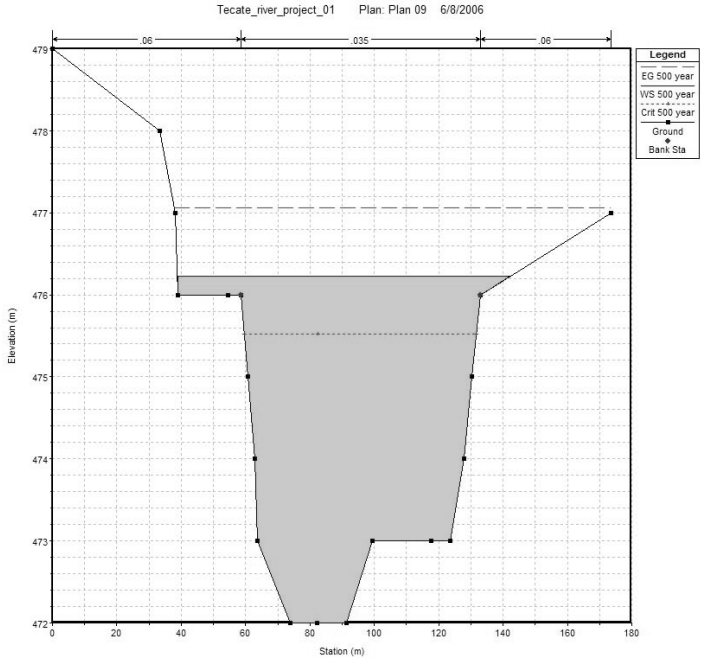

Figure 141. Calculated cross section at RM 0+000, 500-yr frequency

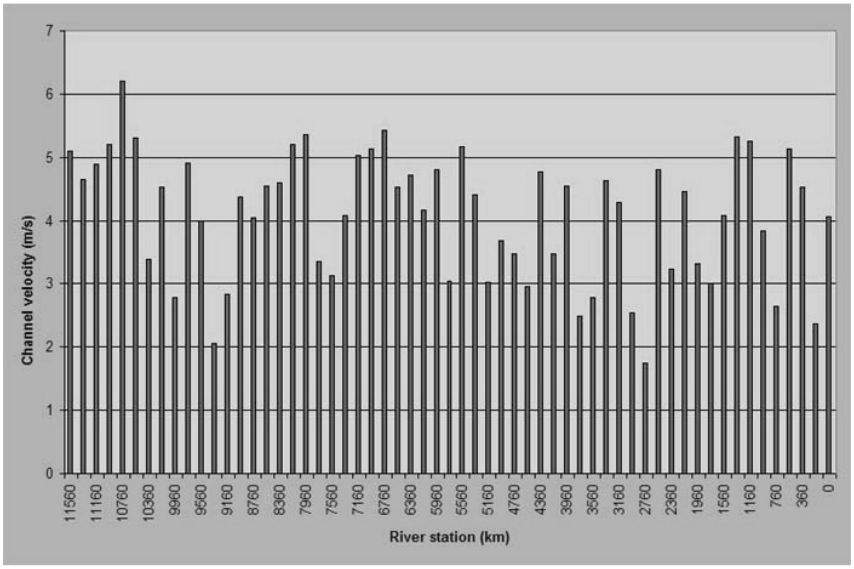

Figure 142. HEC-RAS channel velocities, 500-yr frequency

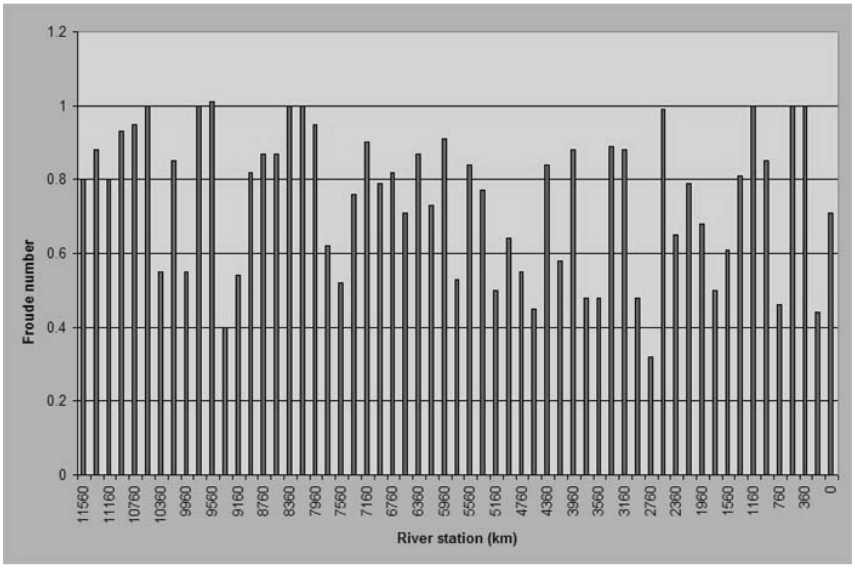

Figure 143. HEC-RAS Froude numbers, 500-yr frequency

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Tecate	11560	500 year	997.00	552.00	557.35	557.35	558.11	0.003915	5.10	429.13	257.46	0.80
Tecate	11360	500 year	997.00	549.00	554.17	554.17	555.21	0.006732	4.65	254.03	163.84	0.88
Tecate	11160	500 year	997.00	548.00	552.70	552.70	553.81	0.003678	4.89	298.95	188.62	0.80
Tecate	10960	500 year	997.00	546.00	550.87	550.87	552.23	0.007315	5.21	210.56	105.25	0.93
Tecate	10760	500 year	997.00	544.00	548.82	548.75	550.37	0.006834	6.20	236.04	78.23	0.95
Tecate	10560	500 year	997.00	544.00	547.35	547.35	548.79	0.008863	5.31	187.68	65.89	1.00
Tecate	10360	500 year	997.00	542.00	546.62		547.14	0.003005	3.39	332.78	100.51	0.55
Tecate	10160	500 year	997.00	541.00	545.14	544.94	546.16	0.008147	4.52	239.04	105.15	0.85
Tecate	9960	500 year	997.00	541.00	544.70		545.10	0.002698	2.79	356.96	137.73	0.55
Tecate	9760	500 year	997.00	539.00	542.89	542.89	544.12	0.009058	4.91	202.88	82.64	1.00
Tecate	9560	500 year	997.00	538.00	540.07	540.07	540.89	0.007745	3.99	249.97	157.04	1.01
Tecate	9360	500 year	997.00	536.00	539.98		540.19	0.001040	2.05	487.18	184.51	0.40
Tecate	9160	500 year	997.00	536.00	539.45		539.86	0.002545	2.84	350.46	125.29	0.54
Tecate	8960	500 year	997.00	535.00	538.29	538.29	539.09	0.005762	4.38	322.77	223.20	0.82
Tecate	8760	500 year	997.00	534.00	536.90	536.85	537.66	0.007080	4.05	303.84	206.97	0.87
Tecate	8560	500 year	997.00	531.00	534.69	534.37	535.74	0.013255	4.55	219.04	77.98	0.87
Tecate	8360	500 year	997.00	529.00	532.80	532.80	533.87	0.006928	4.59	217.35	101.74	1.00
Tecate	8160	500 year	997.00	527.00	531.08	531.08	532.46	0.006420	5.21	191.45	69.57	1.00
Tecate	7960	500 year	997.00	525.00	529.76	529.76	531.20	0.005456	5.36	197.91	79.86	0.95
Tecate	7760	500 year	997.00	524.00	527.87		528.43	0.003188	3.35	314.50	137.83	0.62
Tecate	7560	500 year	997.00	523.00	527.53		527.96	0.001558	3.12	428.71	188.73	0.52
Tecate	7360	500 year	997.00	523.00	526.74	526.74	527.48	0.003573	4.08	368.79	320.42	0.76
Tecate	7160	500 year	997.00	522.00	525.58	525.58	526.20	0.006862	5.03	458.48	327.94	0.90
Tecate	6960	500 year	997.00	519.00	524.25		525.06	0.003580	5.13	393.44	222.19	0.79
Tecate	6760	500 year	997.00	518.00	523.23	523.23	524.21	0.005319	5.42	317.08	144.16	0.82
Tecate	6560	500 year	997.00	516.00	521.09		521.64	0.005207	4.52	431.60	195.25	0.71
Tecate	6360	500 year	997.00	515.00	519.49		520.18	0.011007	4.72	316.12	204.86	0.87
Tecate	6160	500 year	997.00	514.00	517.79		518.15	0.009300	4.16	525.84	517.06	0.73
Tecate	5960	500 year	997.00	512.00	515.54	515.54	516.02	0.012052	4.80	440.53	401.09	0.91
Tecate	5760	500 year	997.00	511.00	514.63		514.84	0.002987	3.05	627.47	340.80	0.53
Tecate	5560	500 year	997.00	509.00	513.27	513.27	514.10	0.004131	5.17	403.68	245.00	0.84
Tecate	5360	500 year	997.00	507.00	510.63		511.10	0.005073	4.41	470.46	363.12	0.77
Tecate	5160	500 year	997.00	506.00	509.96		510.16	0.004251	3.02	659.48	388.62	0.50
Tecate	4960	500 year	997.00	505.00	508.49		508.79	0.013595	3.69	489.58	284.26	0.64
Tecate	4760	500 year	997.00	501.00	506.06		506.36	0.009665	3.47	553.93	366.04	0.55
Tecate	4560	500 year	997.00	500.00	505.03		505.34	0.003107	2.96	465.00	200.70	0.45
Tecate	4360	500 year	997.00	499.00	503.10	503.10	504.16	0.011988	4.77	256.53	135.78	0.84
Tecate	4160	500 year	997.00	497.00	501.65		501.92	0.002722	3.47	517.42	243.52	0.58
Tecate	3960	500 year	997.00	496.00	499.93	499.93	500.75	0.016543	4.55	301.43	195.44	0.88
Tecate	3760	500 year	997.00	496.00	499.13		499.27	0.002631	2.49	797.04	470.05	0.48
Tecate	3560	500 year	997.00	494.00	498.38		498.64	0.003836	2.78	538.29	250.01	0.48
Tecate	3360	500 year	997.00	493.00	496.78	496.78	497.68	0.006815	4.63	327.61	207.32	0.89
Tecate	3160	500 year	997.00	492.00	495.18		495.98	0.006958	4.28	322.18	195.54	0.88
Tecate	2960	500 year	997.00	491.00	494.08		494.35	0.007747	2.54	491.92	235.78	0.48
Tecate	2760	500 year	997.00	489.00	493.69		493.84	0.001130	1.75	589.67	252.36	0.32
Tecate	2560	500 year	997.00	488.00	492.04	492.04	493.21	0.011808	4.81	209.70	92.34	0.99
Tecate	2360	500 year	997.00	488.00	490.87		491.25	0.003680	3.24	506.77	298.42	0.65
Tecate	2160	500 year	997.00	486.00	489.51		490.24	0.006711	4.46	339.53	151.23	0.79
Tecate	1960	500 year	997.00	486.00	488.61		489.15	0.004138	3.31	345.97	189.57	0.68
Tecate	1760	500 year	997.00	483.00	488.04		488.47	0.002572	3.00	396.41	159.16	0.50
Tecate	1560	500 year	997.00	482.00	487.10		487.71	0.005850	4.08	460.55	252.64	0.61
Tecate	1360	500 year	997.00	480.00	485.40	485.40	486.59	0.004945	5.32	307.12	152.50	0.81
Tecate	1160	500 year	997.00	479.00	483.18	483.18	484.58	0.008558	5.25	190.71	76.98	1.00
Tecate	0960	500 year	997.00	478.00	481.63		482.38	0.006837	3.83	260.61	125.75	0.85
Tecate	0760	500 year	997.00	477.00	481.31		481.66	0.001673	2.65	399.72	156.54	0.46
Tecate	0560	500 year	997.00	476.00	479.57	479.57	480.91	0.008864	5.13	194.20	72.87	1.00
Tecate	0360	500 year	997.00	474.00	477.74	477.74	478.79	0.009486	4.53	220.14	105.53	1.00
Tecate	0160	500 year	997.00	473.00	477.23		477.52	0.001626	2.36	423.87	149.66	0.44
Tecate	0000	500 year	997.00	472.00	476.23	475.52	477.06	0.004225	4.06	250.45	103.20	0.71

Figure 144. HEC-RAS summary table, 500-yr frequency

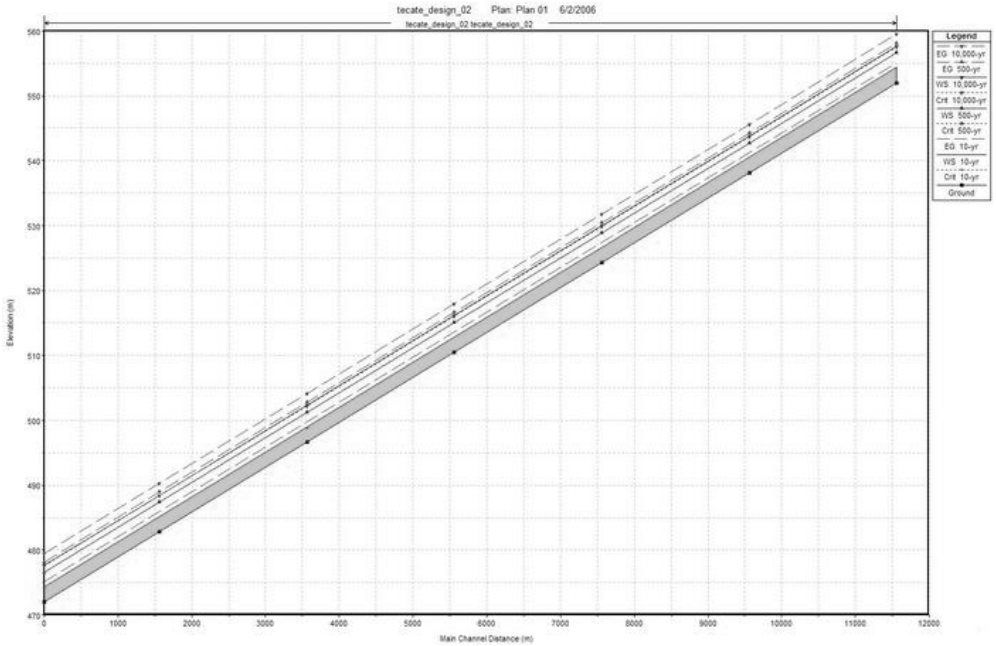

Figure 145. HEC-RAS water-surface profile, design cross section

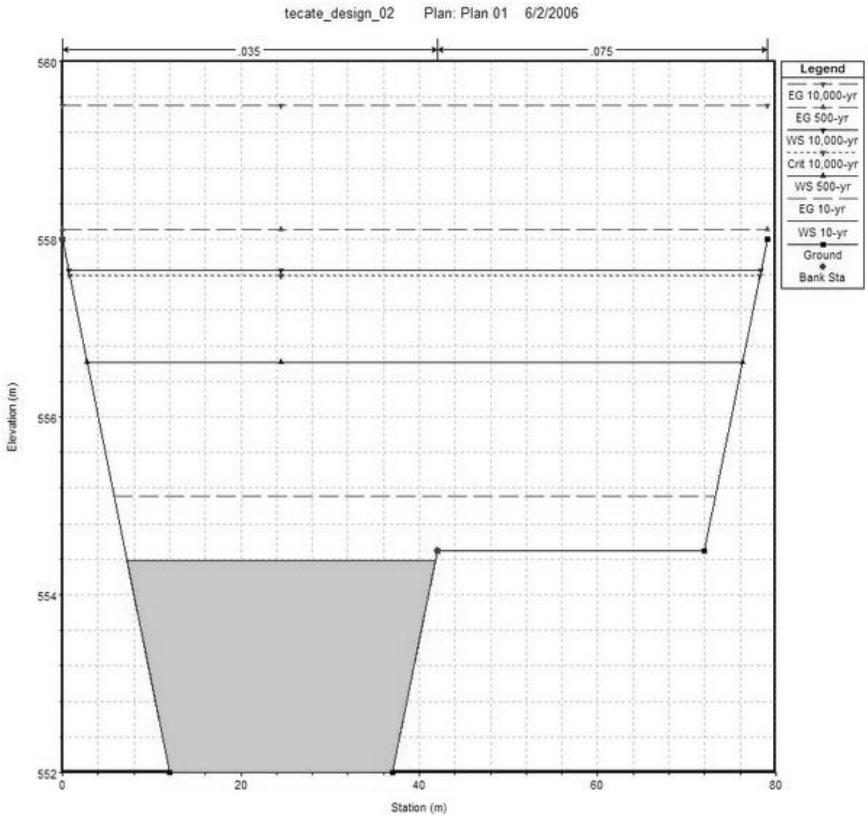

Figure 146. HEC-RAS design cross section at 11+560

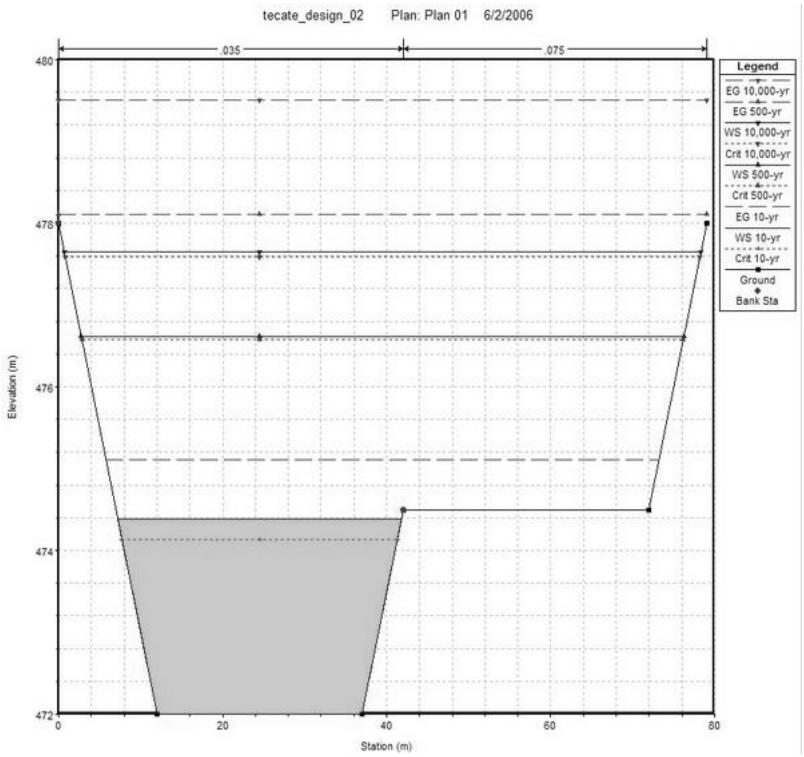

Figure 147. HEC-RAS design cross section at 0+000

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
tecate_design_02	11560	10-yr	268.00	552.00	554.39		555.11	0.006919	3.77	71.18	34.56	0.84
tecate_design_02	11560	500-yr	997.00	552.00	556.61		558.11	0.006907	5.73	221.29	73.45	0.93
tecate_design_02	11560	10,000-yr	1499.00	552.00	557.65	557.59	559.51	0.006923	6.49	299.64	77.60	0.95
tecate_design_02	9560	10-yr	268.00	538.16	540.55		541.27	0.006923	3.77	71.16	34.56	0.84
tecate_design_02	9560	500-yr	997.00	538.16	542.77		544.27	0.006934	5.74	220.96	73.43	0.93
tecate_design_02	9560	10,000-yr	1499.00	538.16	543.81	543.75	545.67	0.006917	6.49	299.74	77.61	0.95
tecate_design_02	7560	10-yr	268.00	524.32	526.71		527.43	0.006919	3.77	71.18	34.56	0.84
tecate_design_02	7560	500-yr	997.00	524.32	528.93		530.43	0.006907	5.73	221.29	73.45	0.93
tecate_design_02	7560	10,000-yr	1499.00	524.32	529.97	529.91	531.83	0.006922	6.49	299.65	77.60	0.95
tecate_design_02	5560	10-yr	268.00	510.48	512.87		513.59	0.006923	3.77	71.16	34.56	0.84
tecate_design_02	5560	500-yr	997.00	510.48	515.09		516.59	0.006934	5.74	220.96	73.43	0.93
tecate_design_02	5560	10,000-yr	1499.00	510.48	516.13	516.07	517.99	0.006920	6.49	299.68	77.60	0.95
tecate_design_02	3560	10-yr	268.00	496.64	499.03	498.77	499.75	0.006916	3.76	71.18	34.56	0.84
tecate_design_02	3560	500-yr	997.00	496.64	501.25		502.75	0.006912	5.73	221.22	73.45	0.93
tecate_design_02	3560	10,000-yr	1499.00	496.64	502.29	502.23	504.15	0.006922	6.49	299.65	77.60	0.95
tecate_design_02	1560	10-yr	268.00	482.80	485.19		485.91	0.006916	3.76	71.19	34.56	0.84
tecate_design_02	1560	500-yr	997.00	482.80	487.41		488.91	0.006932	5.74	220.98	73.44	0.93
tecate_design_02	1560	10,000-yr	1499.00	482.80	488.45	488.39	490.31	0.006922	6.49	299.66	77.60	0.95
tecate_design_02	0000	10-yr	268.00	472.00	474.39	474.13	475.11	0.006932	3.77	71.13	34.55	0.84
tecate_design_02	0000	500-yr	997.00	472.00	476.61	476.57	478.11	0.006921	5.74	221.11	73.44	0.93
tecate_design_02	0000	10,000-yr	1499.00	472.00	477.65	477.59	479.51	0.006924	6.50	299.63	77.60	0.95

Figure 148. HEC-RAS design cross section summary table

Figure 149. Tecate Creek, in Tecate, Baja California