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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
FLUID MECHANICS AND FLOW SYSTEMS

FINAL PROJECT

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1 Introduction

In this report, Beaver Creek, a body of water located near Kentwood, Louisiana, is analyzed. This specific location sees a bridge crossing along Louisiana State Route 1049 arching over Beaver Creek near the center of this reach. Here, field data from the United States Geological Survey (USGS) was used to develop a model under and around the bridge crossing, to evaluate possible floods, as well as evaluate a previous flood that occurred May 22, 1974, where the river experienced a flow of 14,000 cfs. The analysis initially uses pressure/weir flow methods to determine water surface profiles, and then uses energy methods. It evaluates the bridge contraction and expansion reach lengths, adjusted the location of certain cross sections, and calibrated with the observed water surface elevation data. From this calibrated project file, Manning's coefficients and flow rates were changed to test their impact on the behavior of the reach.

2 Methods

In analyzing the behavior of Beaver Creek, provided values for flow rate and Manning's numbers were used. Of the stations listed in the project, five were chosen as locations of interest at which the impact from changing Manning's numbers and flow rates would be observed; these stations were 5.065, 5.21, 5.39, 5.76, and 5.99. These locations were chosen because their locations were of significance in some way: stations 5.065 and 5.99 are the start and end, respectively, of the creek as described in the project file; stations 5.21 and 5.76 were each near a bend in the creek, which could cause interesting behavior; and 5.39 was immediately before the bridge that crosses the creek, which again could cause interesting behavior.

Initial Manning's (n) values were recorded at every station in the project and changed by a coefficient globally applied to all Manning's values in the creek. We chose to halve and double the initial values to observe impact. It is expected that increased Manning's values will decrease the flow rate, as Manning's n represents higher conduit friction. Intuitively, higher friction will tend to slow flow, while the inverse is true for decreased Manning's numbers. However, since flow is fixed at a particular value, the change in Manning's number will impact water surface levels, with a tendency toward higher water surfaces for higher Manning's numbers.

For each station of interest, *Section 3.1* contains tables showing fill, ground, levee, bank station, water surface, energy grade line, and critical level values at each set of Manning's values (initial, halved, and doubled). Similarly, cross sections showing the water level at each station in comparison with the initial energy grade line, water surface, and critical level at each set of Manning's values.

Flow rates were changed as well, to observe its impact. Manning's numbers were kept at initial values, and the flow changed to 1,000 cfs and 10,000 cfs from the initial project value of 5,000 cfs. A table for each station showing levee, bank station, and initial, lowered, and raised for each of the water surfaces, energy grade lines, and critical levels is shown in *Section 3.2* as well as a single graph depicting the same. The use of a single graph is to make comparison between water surface levels for initial, raised, and lowered flow rates visually simple. We expected a higher water surface level for a raised flow rate, and similarly, a lower water surface with a decreased flow rate.

3 Results

3.1 Varying n Values

Station	n_1	n_2	n_3	n_4	n_5	n_6
5.99	0.1	0.14	0.04	0.14	-	-
5.875	0.1	0.12	0.04	0.14	-	-
5.76	0.1	0.04	0.14	-	-	-
5.685	0.09	0.1	0.04	0.1	-	-
5.61	0.08	0.1	0.04	0.06	-	-
5.525	0.07	0.09	0.1	0.04	0.06	-
5.44	0.06	0.1	0.04	0.06	-	-
5.41	0.15	0.25	0.04	0.15	-	-
5.4	-	-	-	-	-	-
5.39	0.15	0.2	0.04	0.2	0.15	0.2
5.29	0.04	0.06	0.04	0.06	-	-
5.21	0.07	0.08	0.04	0.08	0.06	-
5.13	0.1	0.04	0.1	0.06	-	-
5.065	0.1	0.04	0.1	0.08	-	-
5.0	0.1	0.04	0.1	-	-	-

Table 1: Initial n Values

Station	n_1	n_2	n_3	n_4	n_5	n_6
5.99	0.05	0.07	0.02	0.07	-	-
5.875	0.05	0.06	0.02	0.07	-	-
5.76	0.05	0.02	0.07	-	-	-
5.685	0.045	0.05	0.02	0.05	-	-
5.61	0.04	0.05	0.02	0.03	-	-
5.525	0.035	0.045	0.05	0.02	0.03	-
5.44	0.03	0.05	0.02	0.03	-	-
5.41	0.075	0.125	0.02	0.075	-	-
5.4	-	-	-	-	-	-
5.39	0.075	0.1	0.02	0.1	0.075	0.1
5.29	0.02	0.03	0.02	0.03	-	-
5.21	0.035	0.04	0.02	0.04	0.03	-
5.13	0.05	0.02	0.05	0.03	-	-
5.065	0.05	0.02	0.05	0.04	-	-
5.0	0.05	0.02	0.05	-	-	-

Table 2: Halved n Values

Station	n_1	n_2	n_3	n_4	n_5	n_6
5.99	0.2	0.28	0.08	0.28	-	-
5.875	0.2	0.24	0.08	0.28	-	-
5.76	0.2	0.08	0.28	-	-	-
5.685	0.18	0.2	0.08	0.2	-	-
5.61	0.16	0.2	0.08	0.12	-	-
5.525	0.14	0.18	0.2	0.08	0.12	-
5.44	0.12	0.2	0.08	0.12	-	-
5.41	0.3	0.5	0.08	0.3	-	-
5.4	-	-	-	-	-	-
5.39	0.3	0.4	0.08	0.4	0.3	0.4
5.29	0.08	0.12	0.08	0.12	-	-
5.21	0.14	0.16	0.08	0.16	0.12	-
5.13	0.2	0.08	0.2	0.12	-	-
5.065	0.2	0.08	0.2	0.16	-	-
5.0	0.2	0.08	0.2	-	-	-

Table 3: Doubled n Values

3.1.1 Station 5.99

Fill		Ground		Levee	
x	y	x	y	x	y
29.98623	217.3673	0	221	866	214.8
980.2255	217.3673	7	220.3		
948	216.6	36	216.6	Bank Station	
932	209.9	131	216.6	x	y
899	210.2	233	216.8	866	214.8
879	214	282	216.6	948	216.6
866	214.8	351	216.4		
820	211.6	518	216.1	Water Surface	
797	213.7	591	213.3	x	y
771	212.8	627	213.2	29.98623	217.3673
751	210.8	692	209	980.2255	217.3673
738	204.9	709	212.7	932	217.3673
719	209.4	719	209.4		
709	212.7	738	204.9	Energy Grade	
692	209	751	210.8	x	y
627	213.2	771	212.8	28.43089	217.5657
591	213.3	797	213.7	988.5599	217.5657
518	216.1	820	211.6	932	217.5657
351	216.4	866	214.8		
282	216.6	879	214	Critical Level	
233	216.8	899	210.2	x	y
131	216.6	932	209.9	551.6976	214.8075
36	216.6	948	216.6	943.7194	214.8075
		1011	218.1	932	214.8075
		1063	218.7		
		1093	219.1		
		1198	218.5		
		1283	218.2		
		1542	218.4		
		1565	218.1		
		1772	218.1		
		1791	218.4		
		1831	218.9		
		1887	220.4		
		1910	220.8		

Table 4: Initial n Values for Station 5.99

Fill		Ground		Levee	
x	y	x	y	x	y
444.2176	216.2325	0	221	866	214.8
947.1225	216.2325	7	220.3		
932	209.9	36	216.6	Bank Station	
899	210.2	131	216.6	x	y
879	214	233	216.8	866	214.8
866	214.8	282	216.6	948	216.6
820	211.6	351	216.4		
797	213.7	518	216.1	Water Surface	
771	212.8	591	213.3	x	y
751	210.8	627	213.2	444.2176	216.2325
738	204.9	692	209	947.1225	216.2325
719	209.4	709	212.7	932	216.2325
709	212.7	719	209.4		
692	209	738	204.9	Energy Grade	
627	213.2	751	210.8	x	y
591	213.3	771	212.8	35.77097	216.6292
518	216.1	797	213.7	145.9027	216.6292
		820	211.6	274.8409	216.6292
		866	214.8	949.2273	216.6292
		879	214	932	216.6292
		899	210.2		
		932	209.9	Critical Level	
		948	216.6	x	y
		1011	218.1	551.6976	214.8075
		1063	218.7	943.7194	214.8075
		1093	219.1	932	214.8075
		1198	218.5		
		1283	218.2		
		1542	218.4		
		1565	218.1		
		1772	218.1		
		1791	218.4		
		1831	218.9		
		1887	220.4		
		1910	220.8		

Table 5: Halved n Values for Station 5.99

Fill		Ground		Levee	
x	y	x	y	x	y
17.72609	218.9315	0	221	866	214.8
1080.363	218.9315	7	220.3		
1063	218.7	36	216.6	Bank Station	
1011	218.1	131	216.6	x	y
948	216.6	233	216.8	866	214.8
932	209.9	282	216.6	948	216.6
899	210.2	351	216.4		
879	214	518	216.1	Water Surface	
866	214.8	591	213.3	x	y
820	211.6	627	213.2	17.72609	218.9315
797	213.7	692	209	1080.363	218.9315
771	212.8	709	212.7	1122.488	218.9315
751	210.8	719	209.4	1832.176	218.9315
738	204.9	738	204.9	932	218.9315
719	209.4	751	210.8		
709	212.7	771	212.8	Energy Grade	
692	209	797	213.7	x	y
627	213.2	820	211.6	17.13779	219.0066
591	213.3	866	214.8	1085.992	219.0066
518	216.1	879	214	1109.353	219.0066
351	216.4	899	210.2	1834.979	219.0066
282	216.6	932	209.9	932	219.0066
233	216.8	948	216.6		
131	216.6	1011	218.1	Critical Level	
36	216.6	1063	218.7	x	y
1122.488	218.9315	1093	219.1	551.6976	214.8075
1832.176	218.9315	1198	218.5	943.7194	214.8075
1831	218.9	1283	218.2	932	214.8075
1791	218.4	1542	218.4		
1772	218.1	1565	218.1		
1565	218.1	1772	218.1		
1542	218.4	1791	218.4		
1283	218.2	1831	218.9		
1198	218.5	1887	220.4		
0	221	1910	220.8		

Table 6: Doubled n Values for Station 5.99

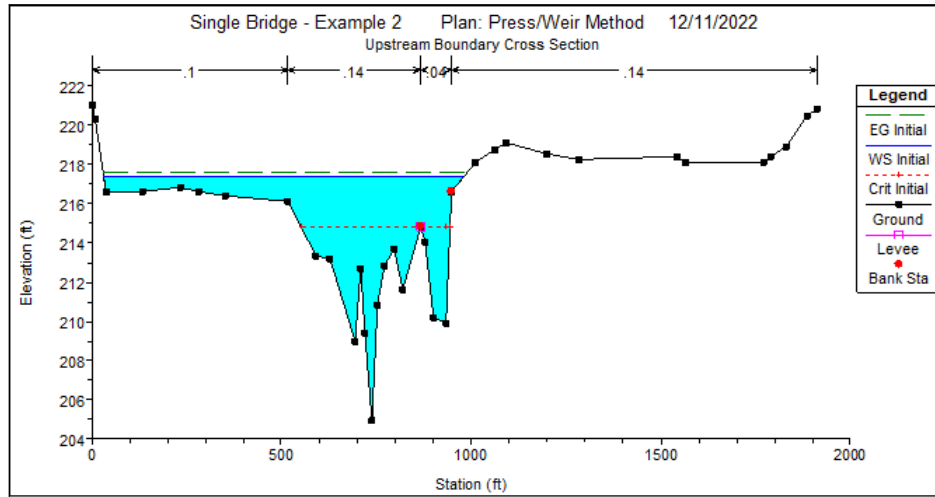


Figure 1: Cross Section for Initial n Values of Station 5.99

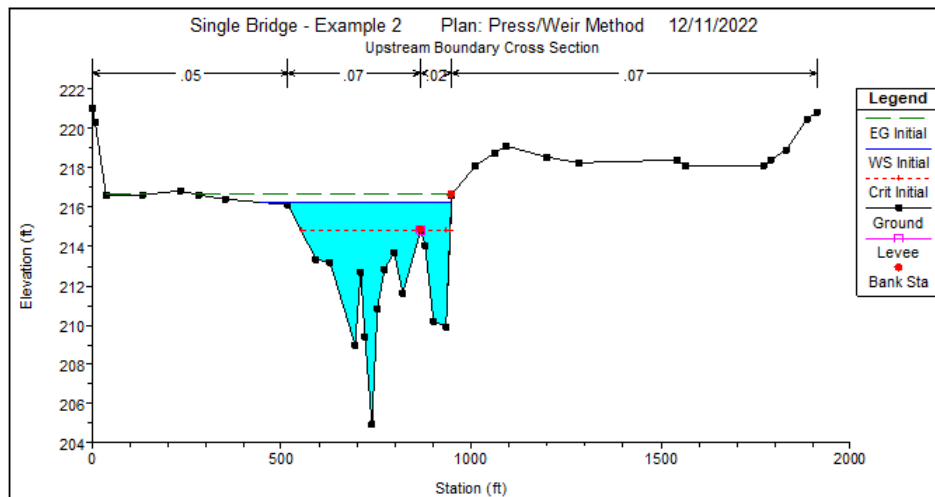


Figure 2: Cross Section for Halved n Values of Station 5.99

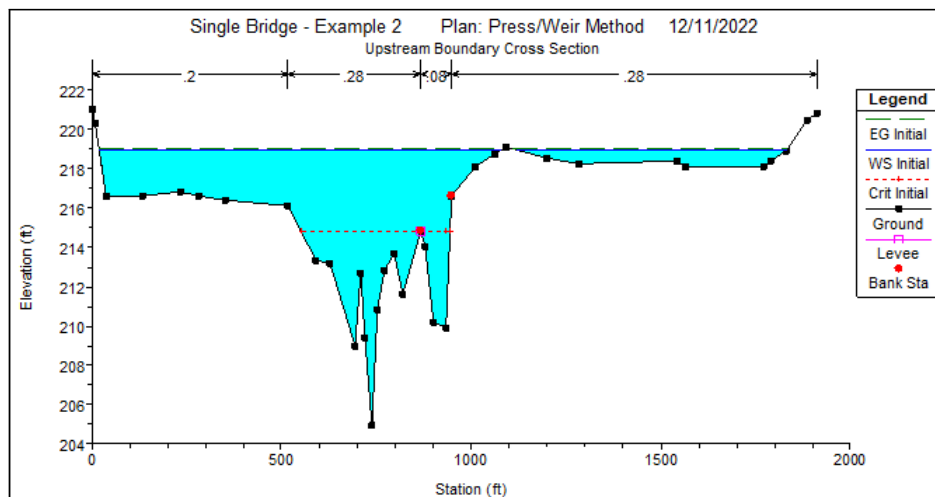


Figure 3: Cross Section for Doubled n Values of Station 5.99

3.1.2 Station 5.76

Fill		Ground		Levee	
x	y	x	y	x	y
58.79404	215.1951	0	218.7	906	214.3
1549.358	215.1951	16	218.1	Bank Station	
1486	214.2	39	216.4	x	y
1463	214	85	213.6	351	214.4
1440	214.5	262	213	548	212.7
1362	213.6	351	214.4	Water Surface	
1332	209	390	210.9	x	y
1250	212	404	206.4	58.79404	215.1951
1240	211.8	423	205	1549.358	215.1951
1139	210.2	446	211.7	423	215.1951
1129	210.3	459	211.5	Energy Grade	
1099	210.3	472	210.1	x	y
1099	209.5	489	211.9	56.87808	215.3118
1079	215	541	212	1556.783	215.3118
1030	210.2	548	212.7	423	215.3118
991	209.6	666	213.9	Critical Level	
981	209.2	705	213.9	x	y
971	213.5	715	213.9	145.7765	213.394
945	213.9	728	213.9	287.0461	213.394
906	214.3	755	213.9	362.2098	213.394
833	213.9	791	213.9	616.242	213.394
814	213.9	814	213.9	423	213.394
791	213.9	833	213.9		
755	213.9	906	214.3		
728	213.9	945	213.9		
715	213.9	971	213.5		
705	213.9	981	209.2		
666	213.9	991	209.6		
548	212.7	1030	210.2		
541	212	1079	215		
489	211.9	1099	209.5		
472	210.1	1099	210.3		
459	211.5	1129	210.3		
446	211.7	1139	210.2		
423	205	1240	211.8		
404	206.4	1250	212		
390	210.9	1332	209		
351	214.4	1362	213.6		
262	213	1440	214.5		
85	213.6	1463	214		
		1486	214.2		
		1677	217.2		
		1805	218.9		

Table 7: Initial n Values for Station 5.76

Fill		Ground		Levee	
x	y	x	y	x	y
83.36731	213.6994	0	218.7	906	214.3
306.4612	213.6994	16	218.1		
262	213	39	216.4	Bank Station	
85	213.6	85	213.6	x	y
358.8068	213.6994	262	213	351	214.4
646.2736	213.6994	351	214.4	548	212.7
548	212.7	390	210.9	Water Surface	
541	212	404	206.4	x	y
489	211.9	423	205	83.36731	213.6994
472	210.1	446	211.7	306.4612	213.6994
459	211.5	459	211.5	358.8068	213.6994
446	211.7	472	210.1	646.2736	213.6994
423	205	489	211.9	423	213.6994
404	206.4	541	212	Energy Grade	
390	210.9	548	212.7	x	y
		666	213.9	66.74715	214.711
		705	213.9	1076.05	214.711
		715	213.9	1080.051	214.711
		728	213.9	1518.537	214.711
		755	213.9	423	214.711
		791	213.9	Critical Level	
		814	213.9	x	y
		833	213.9	145.7765	213.394
		906	214.3	287.0461	213.394
		945	213.9	362.2098	213.394
		971	213.5	616.242	213.394
		981	209.2	423	213.394
		991	209.6		
		1030	210.2		
		1079	215		
		1099	209.5		
		1099	210.3		
		1129	210.3		
		1139	210.2		
		1240	211.8		
		1250	212		
		1332	209		
		1362	213.6		
		1440	214.5		
		1463	214		
		1486	214.2		
		1677	217.2		
		1805	218.9		

Table 8: Halved n Values for Station 5.76

Fill		Ground		Levee	
x	y	x	y	x	y
33.782	216.7857	0	218.7	906	214.3
1650.621	216.7857	16	218.1	Bank Station	
1486	214.2	39	216.4	x	y
1463	214	85	213.6	351	214.4
1440	214.5	262	213	548	212.7
1362	213.6	351	214.4	Water Surface	
1332	209	390	210.9	x	y
1250	212	404	206.4	33.782	216.7857
1240	211.8	423	205	1650.621	216.7857
1139	210.2	446	211.7	423	216.7857
1129	210.3	459	211.5	Energy Grade	
1099	210.3	472	210.1	x	y
1099	209.5	489	211.9	33.23431	216.8262
1079	215	541	212	1653.199	216.8262
1030	210.2	548	212.7	423	216.8262
991	209.6	666	213.9	Critical Level	
981	209.2	705	213.9	x	y
971	213.5	715	213.9	145.7765	213.394
945	213.9	728	213.9	287.0461	213.394
906	214.3	755	213.9	362.2098	213.394
833	213.9	791	213.9	616.242	213.394
814	213.9	814	213.9	423	213.394
791	213.9	833	213.9		
755	213.9	906	214.3		
728	213.9	945	213.9		
715	213.9	971	213.5		
705	213.9	981	209.2		
666	213.9	991	209.6		
548	212.7	1030	210.2		
541	212	1079	215		
489	211.9	1099	209.5		
472	210.1	1099	210.3		
459	211.5	1129	210.3		
446	211.7	1139	210.2		
423	205	1240	211.8		
404	206.4	1250	212		
390	210.9	1332	209		
351	214.4	1362	213.6		
262	213	1440	214.5		
85	213.6	1463	214		
39	216.4	1486	214.2		
0	218.7	1677	217.2		
		1805	218.9		

Table 9: Doubled n Values for Station 5.76

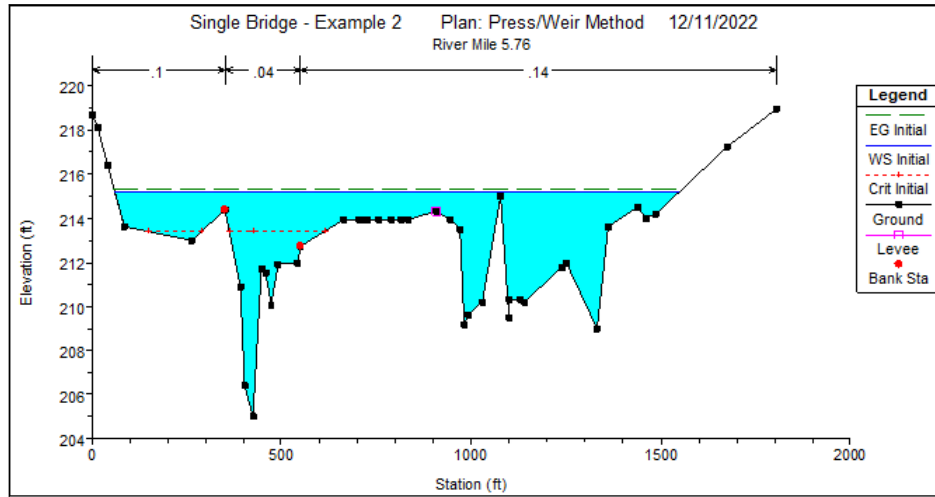


Figure 4: Cross Section for Initial n Values of Station 5.76

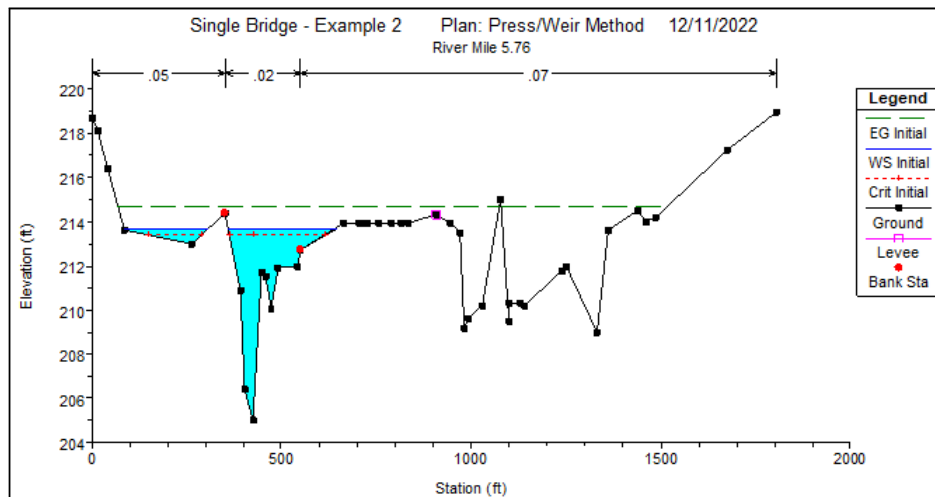


Figure 5: Cross Section for Halved n Values of Station 5.76

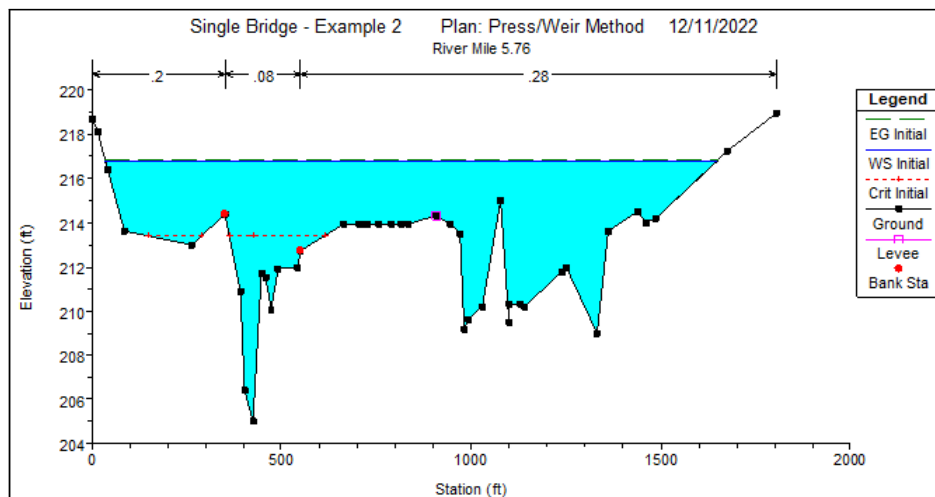


Figure 6: Cross Section for Doubled n Values of Station 5.76

3.1.3 Station 5.39

Fill		Ground		Fill (cont'd)		Ground (cont'd)		Inefficiency	
x	y	x	y	x	y	x	y	x	y
132.172	212.7437	0	216.8	668.2709	212.7437	643.6	213.1	420	211.1329
448.233	212.7437	89	213.6	815.742	212.7437	647	213.5	420	215
443	210.8	210	211.2	692	211.9	692	211.9	677	212.4333
367	211.9	285	210.8	991.0397	212.7437	824	212.8	677	215
285	210.8	367	211.9	1463.4	212.7437	896	213.3	Bank Station	
210	211.2	443	210.8	1421	211.7	961	213.2		
456.9847	212.7437	450	213.4	1371	211.5	1040	212		
642.2935	212.7437	456.6	212.9	1309	210.2	1093	211.7	x	y
640.3	212.2	459.8	211.6	1243	211.1	1116	210	450	213.4
633.7	211.3	466.4	210.1	1116	210	1243	211.1	647	213.5
630.5	209.6	469.7	209.3	1093	211.7	1309	210.2	Water Surface	
623.9	209.3	476.2	208.9	1040	212	1371	211.5		
620.6	209	479.5	208.6			1421	211.7		
614.1	208.7	486.1	208.7			1486	213.3	x	y
610.8	208	489.4	207.9			1558	213.7	132.172	212.7437
604.2	207.5	495.9	208.8			1660	214.7	448.233	212.7437
600.9	206.5	499.2	208.6			1723	215.4	456.9847	212.7437
594.4	205.8	505.8	207.8			1824	217.1	642.2935	212.7437
591.1	204.7	509.1	207.6					668.2709	212.7437
584.5	204	515.6	206.9					815.742	212.7437
581.2	203.6	518.9	204.3					991.0397	212.7437
574.7	202.9	525.5	203.6					1463.4	212.7437
571.4	203	528.7	203.4					548.4	212.7437
564.8	203.8	535.3	203.1					Energy Grade	
561.6	204.4	538.6	202.9						
555	203.1	545.1	203						
548.4	202.7	548.4	202.7					x	y
545.1	203	555	203.1					116.9662	213.0453
538.6	202.9	561.6	204.4					449.0451	213.0453
535.3	203.1	564.8	203.8					454.6819	213.0453
528.7	203.4	571.4	203					643.3994	213.0453
525.5	203.6	574.7	202.9					659.7883	213.0453
518.9	204.3	581.2	203.6					859.3232	213.0453
515.6	206.9	584.5	204					971.184	213.0453
509.1	207.6	591.1	204.7					1475.653	213.0453
505.8	207.8	594.4	205.8					548.4	213.0453
499.2	208.6	600.9	206.5					Critical Level	
495.9	208.8	604.2	207.5						
489.4	207.9	610.8	208						
486.1	208.7	614.1	208.7					x	y
479.5	208.6	620.6	209					476.0116	208.9116
476.2	208.9	623.9	209.3					618.6844	208.9116
469.7	209.3	630.5	209.6					548.4	208.9116
466.4	210.1	633.7	211.3						
459.8	211.6	640.3	212.2						

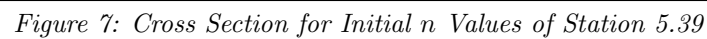
Table 10: Initial n Values for Station 5.39

Fill		Ground		Fill (cont'd)		Ground (cont'd)		Inefficiency	
x	y	x	y	x	y	x	y	x	y
194.9203	211.4991	0	216.8	476.2	208.9	623.9	209.3	420	211.1329
337.1149	211.4991	89	213.6	469.7	209.3	630.5	209.6	420	215
285	210.8	210	211.2	466.4	210.1	633.7	211.3	677	212.4333
210	211.2	285	210.8	1095.718	211.4991	640.3	212.2	677	215
394.6984	211.4991	367	211.9	1370.957	211.4991	643.6	213.1	Bank Station	
444.8822	211.4991	443	210.8	1309	210.2	647	213.5	x	y
443	210.8	450	213.4	1243	211.1	692	211.9	450	213.4
460.244	211.4991	456.6	212.9	1116	210	824	212.8	647	213.5
635.16	211.4991	459.8	211.6			896	213.3	Water Surface	
633.7	211.3	466.4	210.1			961	213.2	x	y
630.5	209.6	469.7	209.3			1040	212	194.9203	211.4991
623.9	209.3	476.2	208.9			1093	211.7	337.1149	211.4991
620.6	209	479.5	208.6			1116	210	394.6984	211.4991
614.1	208.7	486.1	208.7			1243	211.1	444.8822	211.4991
610.8	208	489.4	207.9			1309	210.2	460.244	211.4991
604.2	207.5	495.9	208.8			1371	211.5	635.16	211.4991
600.9	206.5	499.2	208.6			1421	211.7	1095.718	211.4991
594.4	205.8	505.8	207.8			1486	213.3	1370.957	211.4991
591.1	204.7	509.1	207.6			1558	213.7	548.4	211.4991
584.5	204	515.6	206.9			1660	214.7	Energy Grade	
581.2	203.6	518.9	204.3			1723	215.4	x	y
574.7	202.9	525.5	203.6			1824	217.1	171.0083	211.9734
571.4	203	528.7	203.4					446.1591	211.9734
564.8	203.8	535.3	203.1					458.8809	211.9734
561.6	204.4	538.6	202.9					638.6382	211.9734
555	203.1	545.1	203					689.9358	211.9734
548.4	202.7	548.4	202.7					702.7645	211.9734
545.1	203	555	203.1					1044.701	211.9734
538.6	202.9	561.6	204.4					1432.106	211.9734
535.3	203.1	564.8	203.8					548.4	211.9734
528.7	203.4	571.4	203					Critical Level	
525.5	203.6	574.7	202.9					x	y
518.9	204.3	581.2	203.6					476.0116	208.9116
515.6	206.9	584.5	204					618.6844	208.9116
509.1	207.6	591.1	204.7					548.4	208.9116
505.8	207.8	594.4	205.8						
499.2	208.6	600.9	206.5						
495.9	208.8	604.2	207.5						
489.4	207.9	610.8	208						
486.1	208.7	614.1	208.7						
479.5	208.6	620.6	209						
476.2	208.9	623.9	209.3						
469.7	209.3	630.5	209.6						
466.4	210.1	633.7	211.3						
459.8	211.6	640.3	212.2						

Table 11: Halved n Values for Station 5.39

Fill		Ground		Fill (cont'd)		Ground (cont'd)		Inefficiency	
x	y	x	y	x	y	x	y	x	y
63.71426	214.5092	0	216.8	561.6	204.4	584.5	204	420	211.1329
1640.534	214.5092	89	213.6	555	203.1	591.1	204.7	420	215
1558	213.7	210	211.2	548.4	202.7	594.4	205.8	677	212.4333
1486	213.3	285	210.8	545.1	203	600.9	206.5	677	215
1421	211.7	367	211.9	538.6	202.9	604.2	207.5	Bank Station	
1371	211.5	443	210.8	535.3	203.1	610.8	208	x	y
1309	210.2	450	213.4	528.7	203.4	614.1	208.7	450	213.4
1243	211.1	456.6	212.9	525.5	203.6	620.6	209	647	213.5
1116	210	459.8	211.6	518.9	204.3	623.9	209.3	Water Surface	
1093	211.7	466.4	210.1	515.6	206.9	630.5	209.6	x	y
1040	212	469.7	209.3	509.1	207.6	633.7	211.3	63.71426	214.5092
961	213.2	476.2	208.9	505.8	207.8	640.3	212.2	1640.534	214.5092
896	213.3	479.5	208.6	499.2	208.6	643.6	213.1	548.4	214.5092
824	212.8	486.1	208.7	495.9	208.8	647	213.5	Energy Grade	
692	211.9	489.4	207.9	489.4	207.9	692	211.9	x	y
647	213.5	495.9	208.8	486.1	208.7	824	212.8	58.87372	214.6832
643.6	213.1	499.2	208.6	479.5	208.6	896	213.3	1658.286	214.6832
640.3	212.2	505.8	207.8	476.2	208.9	961	213.2	548.4	214.6832
633.7	211.3	509.1	207.6	469.7	209.3	1040	212	Critical Level	
630.5	209.6	515.6	206.9	466.4	210.1	1093	211.7	x	y
623.9	209.3	518.9	204.3	459.8	211.6	1116	210	476.0116	208.9116
620.6	209	525.5	203.6	456.6	212.9	1243	211.1	618.6844	208.9116
614.1	208.7	528.7	203.4	450	213.4	1309	210.2	548.4	208.9116
610.8	208	535.3	203.1	443	210.8	1371	211.5		
604.2	207.5	538.6	202.9	367	211.9	1421	211.7		
600.9	206.5	545.1	203	285	210.8	1486	213.3		
594.4	205.8	548.4	202.7	210	211.2	1558	213.7		
591.1	204.7	555	203.1	89	213.6	1660	214.7		
584.5	204	561.6	204.4	0	216.8	1723	215.4		
581.2	203.6	564.8	203.8			1824	217.1		
574.7	202.9	571.4	203						
571.4	203	574.7	202.9						
564.8	203.8	581.2	203.6						
515.6	206.9	584.5	204						
509.1	207.6	591.1	204.7						
505.8	207.8	594.4	205.8						
499.2	208.6	600.9	206.5						
495.9	208.8	604.2	207.5						
489.4	207.9	610.8	208						
486.1	208.7	614.1	208.7						
479.5	208.6	620.6	209						
476.2	208.9	623.9	209.3						
469.7	209.3	630.5	209.6						
466.4	210.1	633.7	211.3						
459.8	211.6	640.3	212.2						

Table 12: Doubled n Values for Station 5.39



3.1.4 Station 5.21

Fill		Ground		Ground (cont'd)		Levee	
x	y	x	y	x	y	x	y
55.56815	211.7428	0	216.15	974.7	211.83	383.6	209.29
972.1729	211.7428	5.9	215.41	996.6	212.38		
946.3	210.85	83.1	209.71	1015.4	212.64	Bank Station	
943.4	210.72	119.5	208.57	1033.4	213.23	x	y
933	210.59	136.5	207.39	1220.5	213.69	189	206.95
852.7	209.78	161	206.62	1296.6	213.87	246	208.95
782.9	207.83	167	207.34	1332.5	213.95		
776.6	208.32	189	206.95	1466.8	213.78	Water Surface	
758.6	209.3	211.7	205.71	1526.1	213.77	x	y
688.2	209.73	221.4	204.77	1640.1	214.08	55.56815	211.7428
665.6	209.84	227.5	203.79	1650.4	214.19	972.1729	211.7428
598	209.34	227.5	202.24	1740.5	215.7	231.5	211.7428
589.5	209.1	231.5	201.35				
542.1	207.85	236.9	204.06			Energy Grade	
525.9	207.1	236.9	206.01			x	y
513.6	207.41	238.2	206.57			53.87888	211.8675
461.4	208.1	246	208.95			976.194	211.8675
460.6	208.01	292.5	208.94			231.5	211.8675
451.9	207.13	297.8	208.67			Critical Level	
442.4	207.17	308.6	208.24			x	y
435.8	207.29	327.6	209.01			77.36282	210.1336
427.2	208.22	339	209.06			887.7552	210.1336
419.3	208.41	379.8	209.23			231.5	210.1336
402.4	208.96	383.6	209.29				
383.6	209.29	402.4	208.96				
379.8	209.23	419.3	208.41				
339	209.06	427.2	208.22				
327.6	209.01	435.8	207.29				
308.6	208.24	442.4	207.17				
297.8	208.67	451.9	207.13				
292.5	208.94	460.6	208.01				
246	208.95	461.4	208.1				
238.2	206.57	513.6	207.41				
236.9	206.01	525.9	207.1				
236.9	204.06	542.1	207.85				
231.5	201.35	589.5	209.1				
227.5	202.24	598	209.34				
227.5	203.79	665.6	209.84				
221.4	204.77	688.2	209.73				
211.7	205.71	758.6	209.3				
189	206.95	776.6	208.32				
167	207.34	782.9	207.83				
161	206.62	852.7	209.78				
136.5	207.39	933	210.59				
119.5	208.57	943.4	210.72				
83.1	209.71	946.3	210.85				

Table 13: Initial n Values for Station 5.21

Fill		Ground		Ground (cont'd)		Levee	
x	y	x	y	x	y	x	y
69.8126	210.6911	0	216.15	943.4	210.72	383.6	209.29
941.0856	210.6911	5.9	215.41	946.3	210.85		
933	210.59	83.1	209.71	974.7	211.83	Bank Station	
852.7	209.78	119.5	208.57	996.6	212.38	x	y
782.9	207.83	136.5	207.39	1015.4	212.64	189	206.95
776.6	208.32	161	206.62	1033.4	213.23	246	208.95
758.6	209.3	167	207.34	1220.5	213.69		
688.2	209.73	189	206.95	1296.6	213.87	Water Surface	
665.6	209.84	211.7	205.71	1332.5	213.95	x	y
598	209.34	221.4	204.77	1466.8	213.78	69.8126	210.6911
589.5	209.1	227.5	203.79	1526.1	213.77	941.0856	210.6911
542.1	207.85	227.5	202.24	1640.1	214.08	231.5	210.6911
525.9	207.1	231.5	201.35	1650.4	214.19		
513.6	207.41	236.9	204.06	1740.5	215.7	Energy Grade	
461.4	208.1	236.9	206.01			x	y
460.6	208.01	238.2	206.57			64.93721	211.051
451.9	207.13	246	208.95			952.1259	211.051
442.4	207.17	292.5	208.94			231.5	211.051
435.8	207.29	297.8	208.67				
427.2	208.22	308.6	208.24			Critical Level	
419.3	208.41	327.6	209.01			x	y
402.4	208.96	339	209.06			77.36282	210.1336
383.6	209.29	379.8	209.23			887.7552	210.1336
379.8	209.23	383.6	209.29			231.5	210.1336
339	209.06	402.4	208.96				
327.6	209.01	419.3	208.41				
308.6	208.24	427.2	208.22				
297.8	208.67	435.8	207.29				
292.5	208.94	442.4	207.17				
246	208.95	451.9	207.13				
238.2	206.57	460.6	208.01				
236.9	206.01	461.4	208.1				
236.9	204.06	513.6	207.41				
231.5	201.35	525.9	207.1				
227.5	202.24	542.1	207.85				
227.5	203.79	589.5	209.1				
221.4	204.77	598	209.34				
211.7	205.71	665.6	209.84				
189	206.95	688.2	209.73				
167	207.34	758.6	209.3				
161	206.62	776.6	208.32				
136.5	207.39	782.9	207.83				
119.5	208.57	852.7	209.78				
83.1	209.71	933	210.59				
119.5	208.57	943.4	210.72				
83.1	209.71	946.3	210.85				

Table 14: Halved n Values for Station 5.21

Fill		Ground		Ground (cont'd)		Levee	
x	y	x	y	x	y	x	y
35.11595	213.2529	0	216.15	1296.6	213.87	383.6	209.29
1042.703	213.2529	5.9	215.41	1332.5	213.95		
1033.4	213.23	83.1	209.71	1466.8	213.78	Bank Station	
1015.4	212.64	119.5	208.57	1526.1	213.77	x	y
996.6	212.38	136.5	207.39	1640.1	214.08	189	206.95
974.7	211.83	161	206.62	1650.4	214.19	246	208.95
946.3	210.85	167	207.34	1740.5	215.7		
943.4	210.72	189	206.95			Water Surface	
933	210.59	211.7	205.71			x	y
852.7	209.78	221.4	204.77			35.11595	213.2529
782.9	207.83	227.5	203.79			1042.703	213.2529
776.6	208.32	227.5	202.24			231.5	213.2529
758.6	209.3	231.5	201.35				
688.2	209.73	236.9	204.06			Energy Grade	
665.6	209.84	236.9	206.01			x	y
598	209.34	238.2	206.57			34.52758	213.2963
589.5	209.1	246	208.95			1060.372	213.2963
542.1	207.85	292.5	208.94			231.5	213.2963
525.9	207.1	297.8	208.67				
513.6	207.41	308.6	208.24			Critical Level	
461.4	208.1	327.6	209.01			x	y
460.6	208.01	339	209.06			77.36282	210.1336
451.9	207.13	379.8	209.23			887.7552	210.1336
442.4	207.17	383.6	209.29			231.5	210.1336
435.8	207.29	402.4	208.96				
427.2	208.22	419.3	208.41				
419.3	208.41	427.2	208.22				
402.4	208.96	435.8	207.29				
383.6	209.29	442.4	207.17				
379.8	209.23	451.9	207.13				
339	209.06	460.6	208.01				
327.6	209.01	461.4	208.1				
308.6	208.24	513.6	207.41				
297.8	208.67	525.9	207.1				
292.5	208.94	542.1	207.85				
246	208.95	589.5	209.1				
238.2	206.57	598	209.34				
236.9	206.01	665.6	209.84				
236.9	204.06	688.2	209.73				
231.5	201.35	758.6	209.3				
227.5	202.24	776.6	208.32				
227.5	203.79	782.9	207.83				
221.4	204.77	852.7	209.78				
211.7	205.71	933	210.59				
189	206.95	943.4	210.72				
167	207.34	946.3	210.85				
161	206.62	974.7	211.83				
136.5	207.39	996.6	212.38				
119.5	208.57	1015.4	212.64				
83.1	209.71	1033.4	213.23				
0	216.15	1220.5	213.69				

Table 15: Doubled n Values for Station 5.21

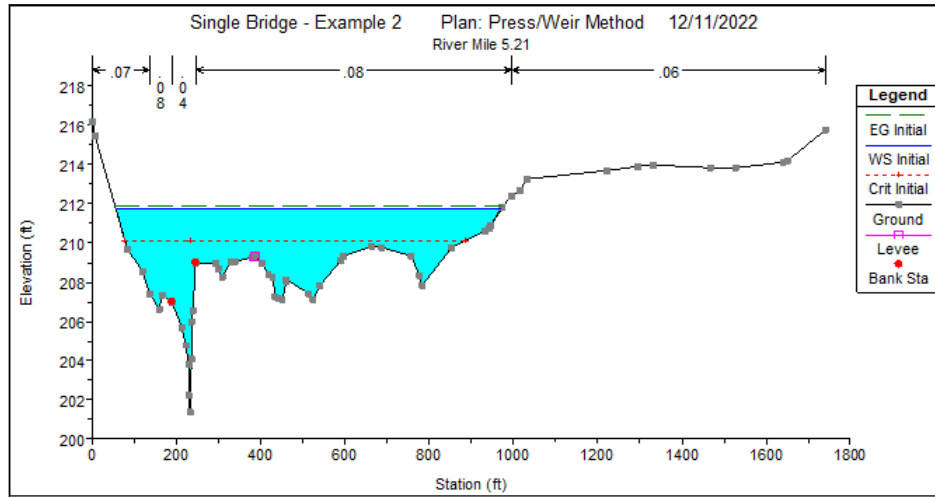


Figure 10: Cross Section for Initial n Values of Station 5.21

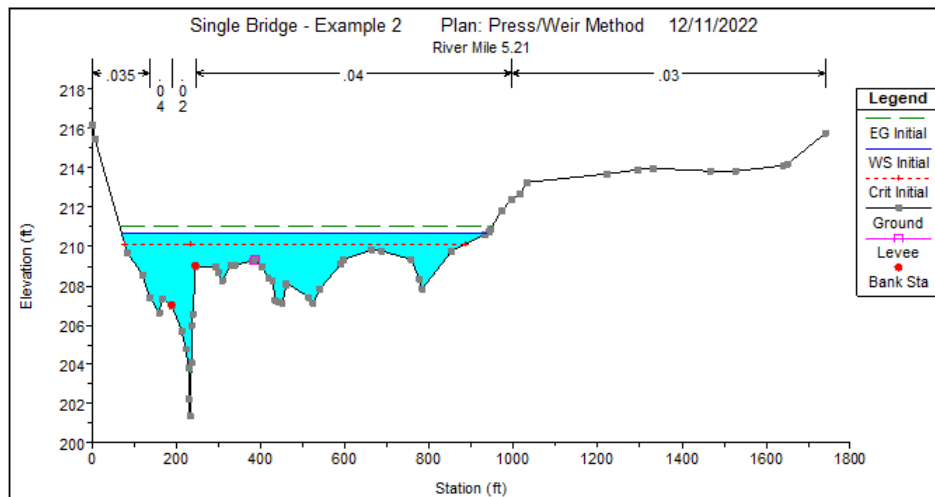


Figure 11: Cross Section for Halved n Values of Station 5.21

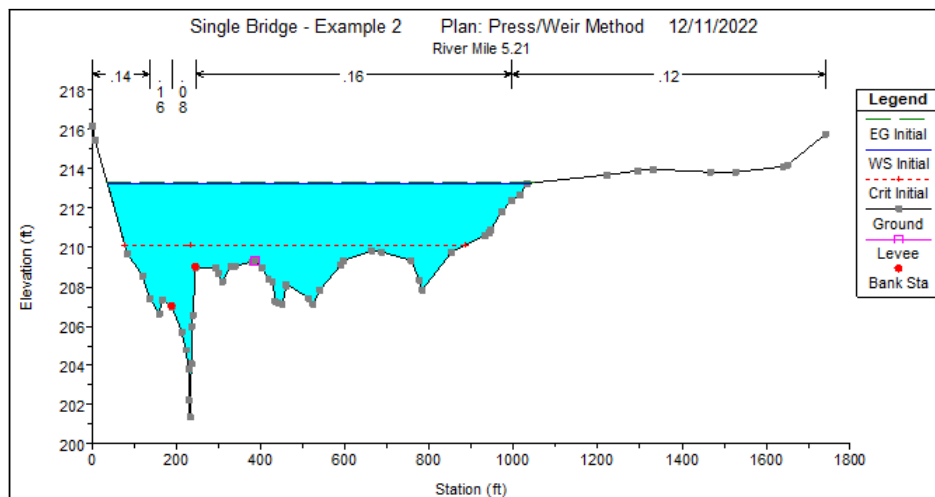


Figure 12: Cross Section for Doubled n Values of Station 5.21

3.1.5 Station 5.065

Fill		Ground		Fill (cont'd)		Ground (cont'd)		Levee	
x	y	x	y	x	y	x	y	x	y
109.3824	210.2814	0	214.45	417.3	208.31	681.4	207.28	365.5	208.6
1119.114	210.2814	11.1	213.86	412.9	208.53	695.9	207.66		
1107.9	210.14	39	212.26	365.5	208.6	722.8	207.77	Bank Station	
1096.7	209.9	41.1	211.82	328.9	205.36	724.1	207.78	x	y
1078.9	209.59	141.4	209.56	328.9	203.41	739.4	207.54	274.5	205.05
1076	209.5	173.5	208.02	316.3	202.12	763.2	208.11	365.5	208.6
1055.3	209.77	274.5	205.05	312.8	200.76	787	209.07	Water Surface	
998.3	209.75	292.9	203.86	307	199.9	816	209.31	Energy Grade	
970.4	209.81	297.1	201.55	299.3	201.33	919.6	210.04	x	y
919.6	210.04	299.3	201.33	297.1	201.55	970.4	209.81	109.3824	210.2814
816	209.31	307	199.9	292.9	203.86	998.3	209.75	1119.114	210.2814
787	209.07	312.8	200.76	274.5	205.05	1055.3	209.77	307	210.2814
763.2	208.11	316.3	202.12	173.5	208.02	1076	209.5	Critical Level	
739.4	207.54	328.9	203.41	141.4	209.56	1078.9	209.59	x	y
724.1	207.78	328.9	205.36			1096.7	209.9	97.48218	210.5496
722.8	207.77	365.5	208.6			1107.9	210.14	1218.028	210.5496
695.9	207.66	412.9	208.53			1130.1	210.42	307	210.5496
681.4	207.28	417.3	208.31			1225.1	210.56	Energy Grade	
667.1	206.76	429.3	206.24			1358.3	211.08	x	y
650.7	205.84	433.9	205.81			1372.2	211.13	97.48218	210.5496
644.1	205.93	441.1	203.43			1418.8	211.28	1218.028	210.5496
638.1	205.98	447.3	206.25			1426.1	210.55	307	210.5496
624.4	205.92	448.6	206.36			1442.6	211.38	Critical Level	
587.1	206.61	487.7	208.09			1472.3	211.49	x	y
584.9	206.68	501.8	208.05			1646.7	211.48	161.41	208.6
575.3	205.82	505.7	208.08			1669.5	211.47	775.3483	208.6
566.4	205.95	550.1	207.01			1745.1	211.67	307	208.6
565.6	205.95	558.8	206.08			1796.2	212.21		
558.8	206.08	565.6	205.95			1868.3	213.44		
550.1	207.01	566.4	205.95			1888	214.2		
505.7	208.08	575.3	205.82						
501.8	208.05	584.9	206.68						
487.7	208.09	587.1	206.61						
448.6	206.36	624.4	205.92						
447.3	206.25	638.1	205.98						
441.1	203.43	644.1	205.93						
433.9	205.81	650.7	205.84						
429.3	206.24	667.1	206.76						

Table 16: Initial n Values for Station 5.065

Fill		Ground		Ground (cont'd)		Levee	
x	y	x	y	x	y	x	y
137.5678	209.6463	0	214.45	998.3	209.75	365.5	208.6
863.7343	209.6463	11.1	213.86	1055.3	209.77		
816	209.31	39	212.26	1076	209.5	Bank Station	
787	209.07	41.1	211.82	1078.9	209.59	x	y
763.2	208.11	141.4	209.56	1096.7	209.9	274.5	205.05
739.4	207.54	173.5	208.02	1107.9	210.14	365.5	208.6
724.1	207.78	274.5	205.05	1130.1	210.42		
722.8	207.77	292.9	203.86	1225.1	210.56	Water Surface	
695.9	207.66	297.1	201.55	1358.3	211.08	x	y
681.4	207.28	299.3	201.33	1372.2	211.13	137.5678	209.6463
667.1	206.76	307	199.9	1418.8	211.28	863.7343	209.6463
650.7	205.84	312.8	200.76	1426.1	210.55	1064.78	209.6463
644.1	205.93	316.3	202.12	1442.6	211.38	1082.136	209.6463
638.1	205.98	328.9	203.41	1472.3	211.49	307	209.6463
624.4	205.92	328.9	205.36	1646.7	211.48		
587.1	206.61	365.5	208.6	1669.5	211.47	Energy Grade	
584.9	206.68	412.9	208.53	1745.1	211.67	x	y
575.3	205.82	417.3	208.31	1796.2	212.21	120.4322	210.0325
566.4	205.95	429.3	206.24	1868.3	213.44	918.5302	210.0325
565.6	205.95	433.9	205.81	1888	214.2	921.2649	210.0325
558.8	206.08	441.1	203.43			1102.881	210.0325
550.1	207.01	447.3	206.25			307	210.0325
505.7	208.08	448.6	206.36				
501.8	208.05	487.7	208.09			Critical Level	
487.7	208.09	501.8	208.05			x	y
448.6	206.36	505.7	208.08			161.41	208.6
447.3	206.25	550.1	207.01			775.3483	208.6
441.1	203.43	558.8	206.08			307	208.6
433.9	205.81	565.6	205.95				
429.3	206.24	566.4	205.95				
417.3	208.31	575.3	205.82				
412.9	208.53	584.9	206.68				
365.5	208.6	587.1	206.61				
328.9	205.36	624.4	205.92				
328.9	203.41	638.1	205.98				
316.3	202.12	644.1	205.93				
312.8	200.76	650.7	205.84				
307	199.9	667.1	206.76				
299.3	201.33	681.4	207.28				
297.1	201.55	695.9	207.66				
292.9	203.86	722.8	207.77				
274.5	205.05	724.1	207.78				
173.5	208.02	739.4	207.54				
141.4	209.56	763.2	208.11				
1064.78	209.6463	787	209.07				
1082.136	209.6463	816	209.31				
1078.9	209.59	919.6	210.04				
1076	209.5	970.4	209.81				

Table 17: Halved n Values for Station 5.065

Fill		Ground		Fill (cont'd)		Ground (cont'd)		Levee	
x	y	x	y	x	y	x	y	x	y
58.87082	211.4196	0	214.45	501.8	208.05	681.4	207.28	365.5	208.6
1453.287	211.4196	11.1	213.86	487.7	208.09	695.9	207.66		
1442.6	211.38	39	212.26	448.6	206.36	722.8	207.77	Bank Station	
1426.1	210.55	41.1	211.82	447.3	206.25	724.1	207.78	x	y
1418.8	211.28	141.4	209.56	441.1	203.43	739.4	207.54	274.5	205.05
1372.2	211.13	173.5	208.02	433.9	205.81	763.2	208.11	365.5	208.6
1358.3	211.08	274.5	205.05	429.3	206.24	787	209.07		
1225.1	210.56	292.9	203.86	417.3	208.31	816	209.31	Water Surface	
1130.1	210.42	297.1	201.55	412.9	208.53	919.6	210.04	x	y
1107.9	210.14	299.3	201.33	365.5	208.6	970.4	209.81	58.87082	211.4196
1096.7	209.9	307	199.9	328.9	205.36	998.3	209.75	1453.287	211.4196
1078.9	209.59	312.8	200.76	328.9	203.41	1055.3	209.77	307	211.4196
1076	209.5	316.3	202.12	316.3	202.12	1076	209.5		
1055.3	209.77	328.9	203.41	312.8	200.76	1078.9	209.59	Energy Grade	
998.3	209.75	328.9	205.36	307	199.9	1096.7	209.9	x	y
970.4	209.81	365.5	208.6	299.3	201.33	1107.9	210.14	54.24223	211.5239
919.6	210.04	412.9	208.53	297.1	201.55	1130.1	210.42	1689.866	211.5239
816	209.31	417.3	208.31	292.9	203.86	1225.1	210.56	307	211.5239
787	209.07	429.3	206.24	274.5	205.05	1358.3	211.08		
763.2	208.11	433.9	205.81	173.5	208.02	1372.2	211.13	Critical Level	
739.4	207.54	441.1	203.43	141.4	209.56	1418.8	211.28	x	y
724.1	207.78	447.3	206.25			1426.1	210.55	161.41	208.6
722.8	207.77	448.6	206.36			1442.6	211.38	775.3483	208.6
695.9	207.66	487.7	208.09			1472.3	211.49	307	208.6
681.4	207.28	501.8	208.05			1646.7	211.48		
667.1	206.76	505.7	208.08			1669.5	211.47		
650.7	205.84	550.1	207.01			1745.1	211.67		
644.1	205.93	558.8	206.08			1796.2	212.21		
638.1	205.98	565.6	205.95			1868.3	213.44		
624.4	205.92	566.4	205.95			1888	214.2		
587.1	206.61	575.3	205.82						
584.9	206.68	584.9	206.68						
575.3	205.82	587.1	206.61						
566.4	205.95	624.4	205.92						
565.6	205.95	638.1	205.98						
558.8	206.08	644.1	205.93						
550.1	207.01	650.7	205.84						
505.7	208.08	667.1	206.76						

Table 18: Doubled n Values for Station 5.065

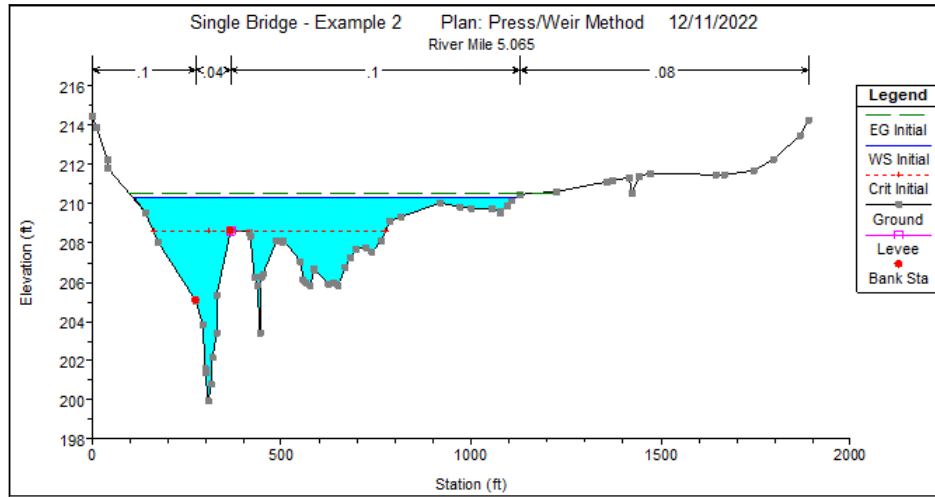


Figure 13: Cross Section for Initial n Values of Station 5.065

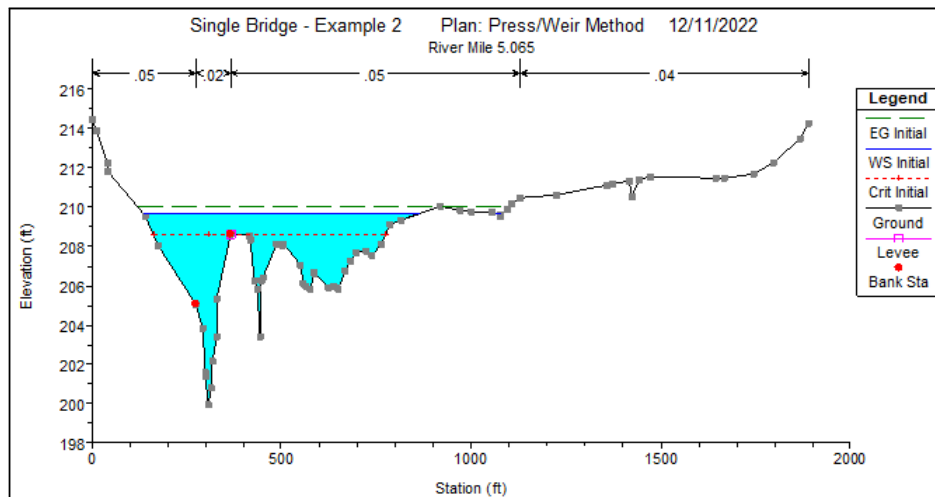


Figure 14: Cross Section for Halved n Values of Station 5.065

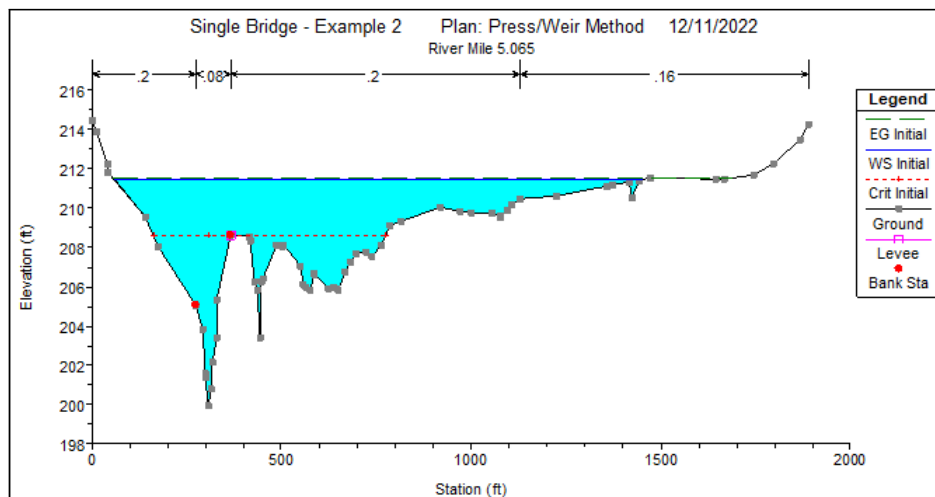


Figure 15: Cross Section for Doubled n Values of Station 5.065

3.2 Varying Flows

3.2.1 Station 5.99

Levee		Raised Water Surface		Lowered Outer Water Surface	
x	y	x	y	x	y
866	214.80	17.49	218.96	9.35	220.00
Bank Station		1082.59	218.96	1872.07	220.00
		1117.28	218.96	932.00	220.00
		1833.29	218.96	Lowered Water Surface	
x	y	932.00	218.96		
866	214.80	Raised Energy Grade			
948	216.60				
Initial Water Surface				x	y
x	y	15.18	219.26	867.69	214.70
29.99	217.37	1844.29	219.26	943.45	214.70
980.23	217.37	932.00	219.26	932.00	214.70
932.00	217.37	Raised Critical Level		Lowered Energy Grade	
Initial Energy Grade					
x	y				
28.43	217.57	523.72	215.88	547.36	214.97
988.56	217.57	946.28	215.88	944.12	214.97
932.00	217.57	932.00	215.88	932.00	214.97
Initial Critical Level				Lowered Critical Level	
x	y				
551.70	214.81				
943.72	214.81				
932.00	214.81				

Table 19: Flow Values for Station 5.99

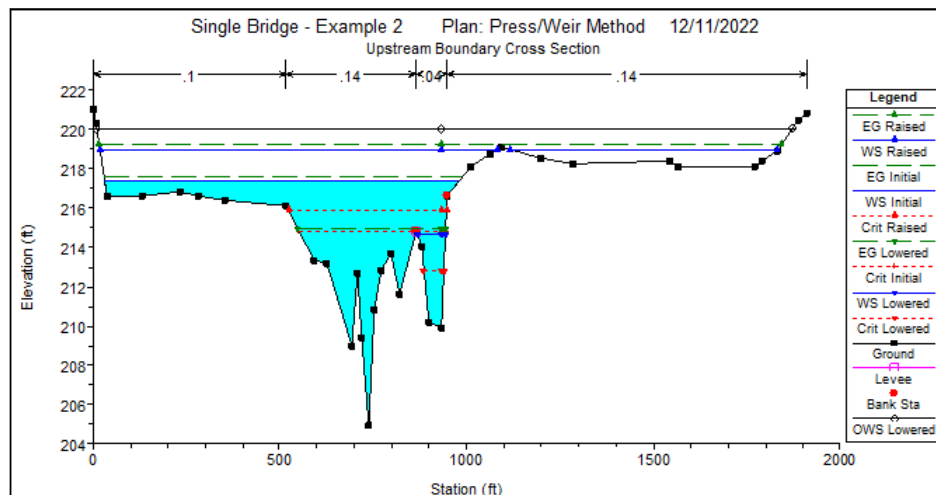


Figure 16: Cross Section for Varying Flows of Station 5.99

3.2.2 Station 5.79

Levee	Raised Water Surface		Lowered Outer Water Surface	
x	x	y	x	y
906	31.14926	216.9803	8.000203	218.4
	1663.011	216.9803	1767.353	218.4
Bank Station	423	216.9803	423	218.4
x	Raised Energy Grade		Lowered Energy Grade	
y	x	y	x	y
351	29.17506	217.1262	369.5518	212.7351
548	1672.301	217.1262	551.451	212.7351
Initial Water Surface	423	217.1262	423	212.7351
x	Raised Critical Level		Lowered Water Surface	
y	x	y	x	y
58.79404	73.49975	214.3	370.5986	212.6411
1549.358	344.6444	214.3	547.4114	212.6411
423	352.114	214.3	423	212.6411
Initial Energy Grade	1071.854	214.3	Lowered Critical Level	
x	1081.545	214.3	x	y
y	1422.668	214.3	395.2366	209.2168
56.87808	1449.199	214.3	437.4756	209.2168
1556.783	1492.368	214.3	423	209.2168
423	423	214.3		
Initial Critical Level				
x				
y				
145.7765				
287.0461				
362.2098				
616.242				
423				

Table 20: Flow Values for Station 5.76

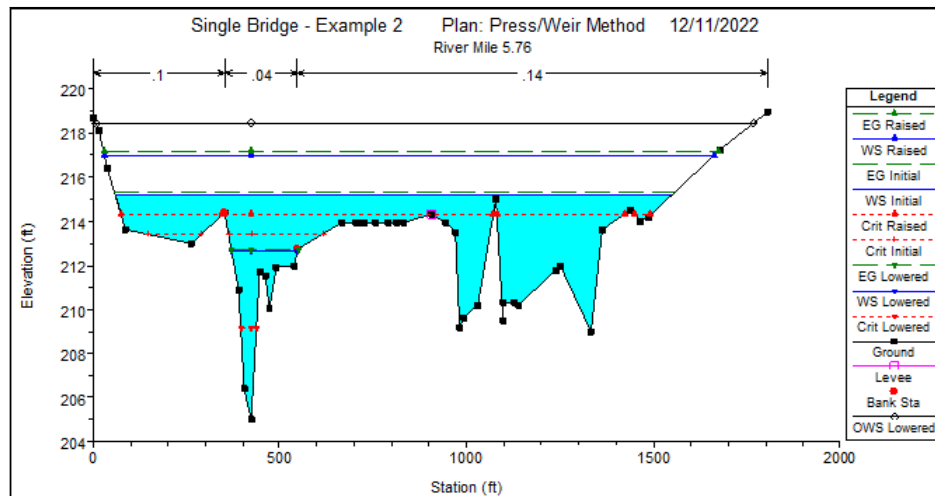


Figure 17: Cross Section for Varying Flows of Station 5.76

3.2.3 Station 5.39

Levee		Raised Water Surface		Lowered Outer Water Surface	
x	y	x	y	x	y
420	211.1329	66.58905	214.4058	44.50021	215.2
420	215	1629.991	214.4058	1705	215.2
677	212.4333	548.4	214.4058	548.4	215.2
677	215				
Bank Station		Raised Energy Grade		Lowered Water Surface	
x	y	x	y	x	y
450	213.4	46.65439	215.1225	175.4502	211.8853
647	213.5	1698.029	215.1225	365.9035	211.8853
		548.4	215.1225	368.0163	211.8853
Initial Water Surface		Raised Critical Level		445.9219	211.8853
x	y	x	y	459.0977	211.8853
132.172	212.7437	257.4308	210.947	637.9921	211.8853
448.233	212.7437	295.9608	210.947	1060.266	211.8853
456.9847	212.7437	432.8412	210.947	1428.527	211.8853
642.2935	212.7437	443.3959	210.947	548.4	211.8853
668.2709	212.7437	462.6731	210.947	Lowered Energy Grade	
815.742	212.7437	633.0356	210.947	x	y
991.0397	212.7437	1103.187	210.947	174.6255	211.9016
1463.4	212.7437	1225.339	210.947	445.966	211.9016
548.4	212.7437	1254.218	210.947	459.0575	211.9016
Initial Energy Grade		1344.628	210.947	638.1121	211.9016
x	y	548.4	210.947	691.9537	211.9016
116.9662	213.0453			692.2417	211.9016
449.0451	213.0453			1057.376	211.9016
454.6819	213.0453			1429.192	211.9016
643.3994	213.0453			548.4	211.9016
659.7883	213.0453			Lowered Critical Level	
859.3232	213.0453			x	y
971.184	213.0453			517.6659	205.2723
1475.653	213.0453			592.817	205.2723
548.4	213.0453			548.4	205.2723
Initial Critical Level					
x	y				
476.0116	208.9116				
618.6844	208.9116				
548.4	208.9116				

Table 21: Flow Values for Station 5.39

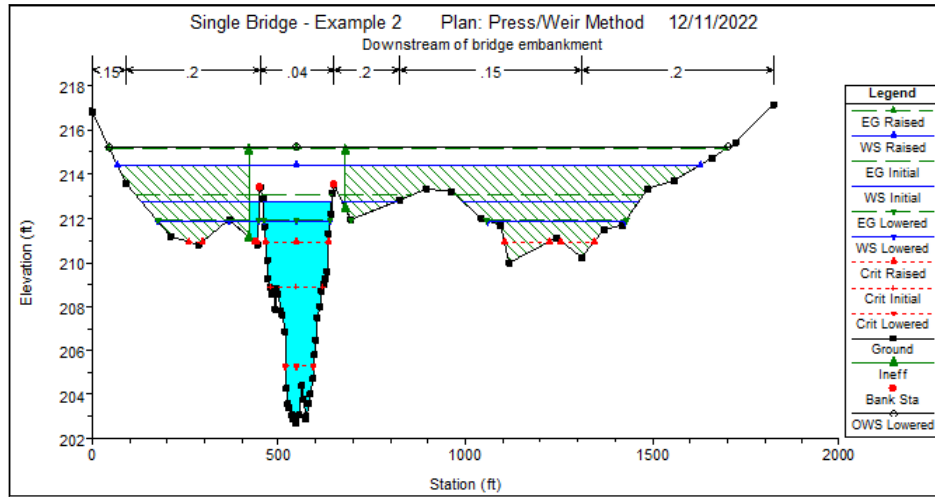


Figure 18: Cross Section for Varying Flows of Station 5.39

3.2.4 Station 5.21

Levee		Raised Water Surface		Lowered Water Surface	
x	y	x	y	x	y
383.6	209.29	32.45682	213.4492	54.37818	211.8307
Bank Station		1122.559	213.4492	974.7261	211.8307
		231.5	213.4492	231.5	211.8307
		Raised Energy Grade		Lowered Energy Grade	
x	y	x	y	x	y
189	206.95	30.35671	213.6043	54.31536	211.8353
246	208.95	1185.627	213.6043	974.9108	211.8353
Initial Water Surface		231.5	213.6043	231.5	211.8353
x	y	Raised Critical Level		Lowered Critical Level	
55.56815	211.7428	x	y	x	y
972.1729	211.7428	64.83223	211.0588	133.3764	207.6068
231.5	211.7428	952.3505	211.0588	241.5979	207.6068
Initial Energy Grade		231.5	211.0588	231.5	207.6068
x	y				
53.87888	211.8675				
976.194	211.8675				
231.5	211.8675				
Initial Critical Level					
x	y				
77.36282	210.1336				
887.7552	210.1336				
231.5	210.1336				

Table 22: Flow Values for Station 5.21

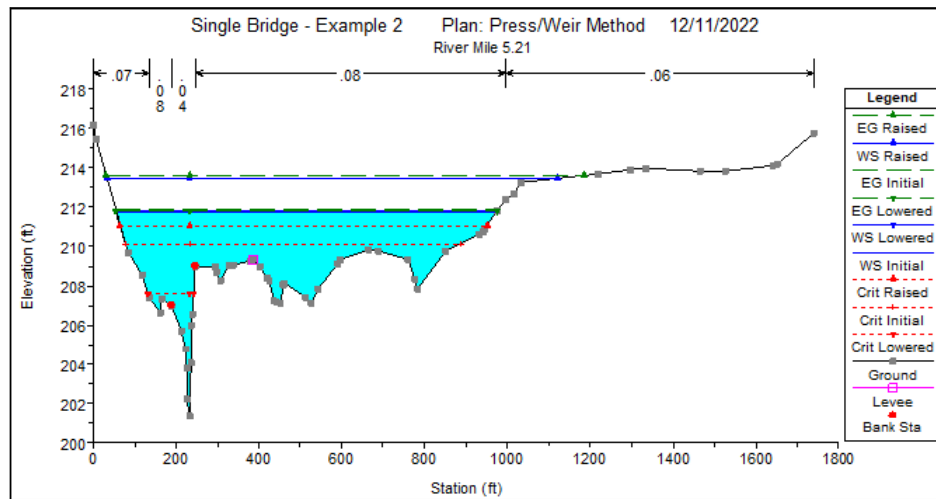


Figure 19: Cross Section for Varying Flows of Station 5.21

3.2.5 Station 5.065

Levee	Raised Water Surface		Lowered Outer Water Surface	
x	x	y	x	y
365.5	48.87888	211.6447	34.81492	212.5
	1735.548	211.6447	1813.199	212.5
Bank Station	307	211.6447	307	212.5
x	Raised Energy Grade		Lowered Water Surface	
y	x	y	x	y
274.5	40.2533	211.9974	41.80428	211.8041
365.5	1776.082	211.9974	1757.793	211.8041
Initial Water Surface	307	211.9974	307	211.8041
x	Raised Critical Level		Lowered Energy Grade	
y	x	y	x	y
109.3824	135.4191	209.6948	41.66681	211.8072
1119.114	870.6054	209.6948	1758.087	211.8072
307	1061.068	209.6948	307	211.8072
Initial Energy Grade	1084.916	209.6948	Lowered Critical Level	
x			x	y
y			279.3643	204.7354
97.48218			328.9	204.7354
1218.028			307	204.7354
307				
Initial Critical Level				
x				
y				
161.41				
775.3483				
307				

Table 23: Flow Values for Station 5.065

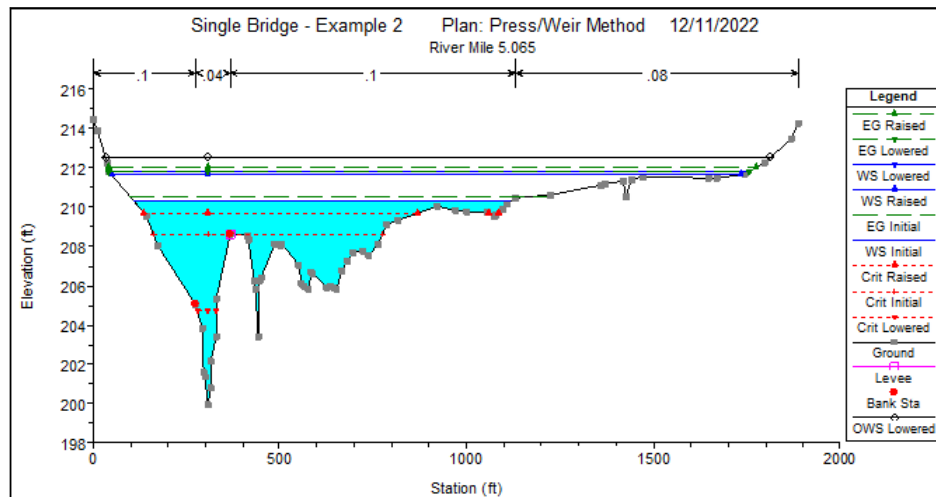


Figure 20: Cross Section for Varying Flows of Station 5.065

4 Discussion

4.1 Altering the Manning's Coefficient

To see how the water surface elevation of an open channel changes as the Manning's coefficient changes, while keeping all other variables constant, we can look at Manning's equation for open channel flow.

Manning's equation for open channel flow is written as:

$$V = \frac{R_h^{\frac{2}{3}} S_0^{\frac{1}{2}}}{n}$$

and

$$Q = VA = \frac{\kappa}{n} A R_h^{\frac{2}{3}} S_0^{\frac{1}{2}}$$

With n representing the manning resistance coefficient. This roughness coefficient represents the friction that is applied to the flow by the channel, as water passes through.

This equation shows, that as the manning coefficient decreases, the open channel flow should increase, as there is less resistance along the wetted perimeter of the channel.

When just relating n to Q , we cannot immediately say that the change in flow leads to any specific change in water surface elevation. By keeping κ , A , R_h , and S_0 constant, while changing the Manning's coefficient, we see that the flow would inversely relate. However, when generating the plots through HEC RAS, when halving and doubling the Manning's coefficient, value for flow was also kept constant. Because of this, we look at the relationship between n and R_h .

The open channel flow equation can be rearranged as follows:

$$R_h^{\frac{2}{3}} = \frac{QAn}{\kappa S_0^{\frac{1}{2}}}$$

By rearranging the equation, we see that there is a direct relationship between R_h and n . R_h is defined as the hydraulic radius of the open channel. In the case of open channel flow, the hydraulic radius is directly related to the water surface elevation in the channel. Because of the direct relationship between R_h and elevation, and the direct relationship between R_h and n , we can say that n and elevation are directly related. Therefore, when halving the Manning's coefficient, n , the water elevation should decrease, and when doubling the Manning's coefficient, n , the water elevation should increase.

For the cross-sectional views of the river for our chosen stations (See *Section 3.1*), you can see this direct relationship, where the plots generated from a halved Manning's coefficient displayed a lower fill in elevation of where the water was, and the plots generated from a doubling Manning's coefficient displayed a lower fill in elevation. These results and equation analysis fall in line with our hypotheses that were made in *Section 2 Methods*, for how the water surface elevation should change with a change in Manning's coefficient.

4.2 Altering the Flow

To see how the water surface elevation of an open channel changes as the flow through the channel changes, while keeping all other variables constant, we can also look at Manning's equation for open channel flow.

Writing Manning's equation for open channel flow as:

$$Q = VA = \frac{\kappa}{n} AR_h^{\frac{2}{3}} S_0^{\frac{1}{2}}$$

As discussed in *Section 4.1*, we know that the hydraulic radius, R_h , is directly related to the surface level elevation. Knowing this direct relationship between R_h and elevation, we can say that Q and elevation are directly related. Therefore, when increasing the flow, while holding all other variables constant, the water surface elevation will increase, and when decreasing flow, the water surface elevation will decrease.

For the cross-sectional views of the river for our chosen stations (See *Section 3.2*), you can see this direct relationship, where the plots generated from increasing the channel's flow displayed a higher elevation for where the water was, and the plots generated from a decreasing the channel's flow displayed a higher elevation. These results and equation analysis fall in line with our hypotheses that were made in *Section 2 Methods*, for how the water surface elevation should change with a change in flow.

5 Conclusion

Taking a flow rate of 5000 cfs as the default flow value, the two scenarios were analyzed, where flow is decreased to 1000 cfs, and increased to 10000 cfs. As expected, the average water level dropped three feet across the entire river. Interestingly, station 5.21 and station 5.065 have a similar surface level, even when decreasing the flow by one-tenth. However, these two stations are located after the bridge, where the change of width becomes very minuscule. For the increased flow, we have a steady increase of approximately 1.6 ± 0.2 ft from the initial flow.

For the changed n -values, this analysis took the initial n -values presented and multiplied them by 0.5 and 2.0, resulting in three data: original, halved, and doubled. We see decreased values for all halved values but doubled manning n -values have varying results. While we have a raised surface level at the beginning of the river, by the next analyzed station, the water surface level, while higher than the halved water surface level, is not as high as the original water surface level. This pattern repeats until the last station, station 5.065, where the pattern reverts to station 5.99, where the doubled manning n -values is higher than the initial, and the halved n -values have a lowered surface level than the original.