

Updated Hydraulic Analysis of Janes Creek

Foster Avenue Development

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Background

The Foster Avenue Development is to be located within the City of Arcata. The project area is bounded to the North by Single Family Homes, to the East by apartment buildings and Janes Creek, to the South by Foster Avenue, and to the West by open agricultural land. The project consists of a 43-acre master planned community.

As part of the Foster Avenue Development Project, improvements to the Lumberyard Road and Foster Avenue crossings are being made. The primary purpose of these improvements is to improve fish passage along Janes Creek. Foster Avenue will also be raised above the 100-year floodplain to accommodate emergency vehicular access.

The existing crossing at Foster Avenue is a 6-foot diameter corrugated metal pipe (CMP) culvert. The existing crossing at Lumberyard Road consists of a 7 foot wide by 4.2-foot high box culvert. The planned improvements will replace the existing culverts with CMP arch culverts. The County is concerned that the changes made at the Foster Avenue and Lumberyard Road crossings may affect flooding conditions at 17th Street (located downstream from the two crossings) and may create changes in floodplain elevations at and near the crossings.

The purpose of this analysis is to size the culverts and modify the Foster Avenue Roadway profile such that the effects on the floodplain are minimal, emergency vehicular access is provided and channel flows are essentially unchanged with the proposed improvements. Additionally the crossing at Foster Avenue must be raised to remove the road from the 100-year floodplain allowing access during a flood event. An alternative to install clear span bridges was also analyzed.

Methodology

In order to evaluate the hydraulic effects on 17th Street and the overall effects on the floodplain due to the proposed changes at Foster Avenue and Lumberyard Road, a HEC-RAS hydraulic model was developed for a section of Janes Creek through the project area. Typical creek cross sections surveyed between 17th Street and Foster Avenue were used along with cross sections taken from the project site survey between Foster Avenue and Lumberyard Road to develop the model. Survey information on each of the three crossings of interest was also used in the model. All survey information was provided by Kelly-O'Hern Associates.

Existing Conditions Model

To evaluate the affects of the road crossings an existing conditions model and a proposed condition model were developed. The existing model was originally calibrated to closely match the flood profiles developed by FEMA. This was achieved using the FEMA Flood Insurance Study flood flows and adjusting channel Manning's n-values until a similar water surface profile resulted. The overall composite calibration n-value was 0.04.

After further review of the channel and floodplain vegetative growth, the existing conditions model was re-run to best reflect existing conditions rather than attempting to match FEMA floodplain elevations. The existing creek banks have a considerable amount of brush and other vegetative growth. A view of Janes Creek near Foster Road is shown in Figure 1 below. A Manning's n-value of 0.03 was selected for the low flow channel and a value of 0.06 was selected for the overbanks to reflect the existing conditions.



Figure 1. View of Janes Creek downstream of Foster Ave crossing

A downstream water surface elevation from the FEMA flood profile was used as the downstream boundary condition below 17th Street for the 100-year flood profile. A 100-year flow rate of 1,030 cfs (from the FEMA FIS study) was used in the modeling efforts. In addition to the 100-year evaluation, hydraulic modeling for the 2-year, 10-year, 25-year and 50-year were also requested. The 10-year flow rate of 610 cfs and the 50-year flow rate of 920 cfs were taken from the FEMA FIS study. Additional flows for the 2-year (275 cfs) and 25-year (875 cfs) were extrapolated from a plot of the data. Boundary conditions for the 2-year, 10-year, 25-year and 50-year profiles were estimated using normal depth. Table 1 below summarizes the flow rates for each flood frequency analyzed.

Table 1. Flow rate summary

Flood Frequency	Peak Flow Rate (cfs)
2-year	275
10-year	610
25-year	875
50-year	920
100-year	1030

Existing Conditions Results

The project area lies within the City of Arcata, California in Humboldt County, FEMA Community Panel Number 060061 0002 E and 060060 0615 D. According to the current FEMA 100-year FIRM map and Flood Insurance Study (FIS) (dated November 5, 1997), both the Foster Avenue and Lumberyard Road crossings overtop during the 100-year flood event. The FEMA 100-year FIRM Map and flood profile for the project area are shown in Figure 2 and Figure 3.

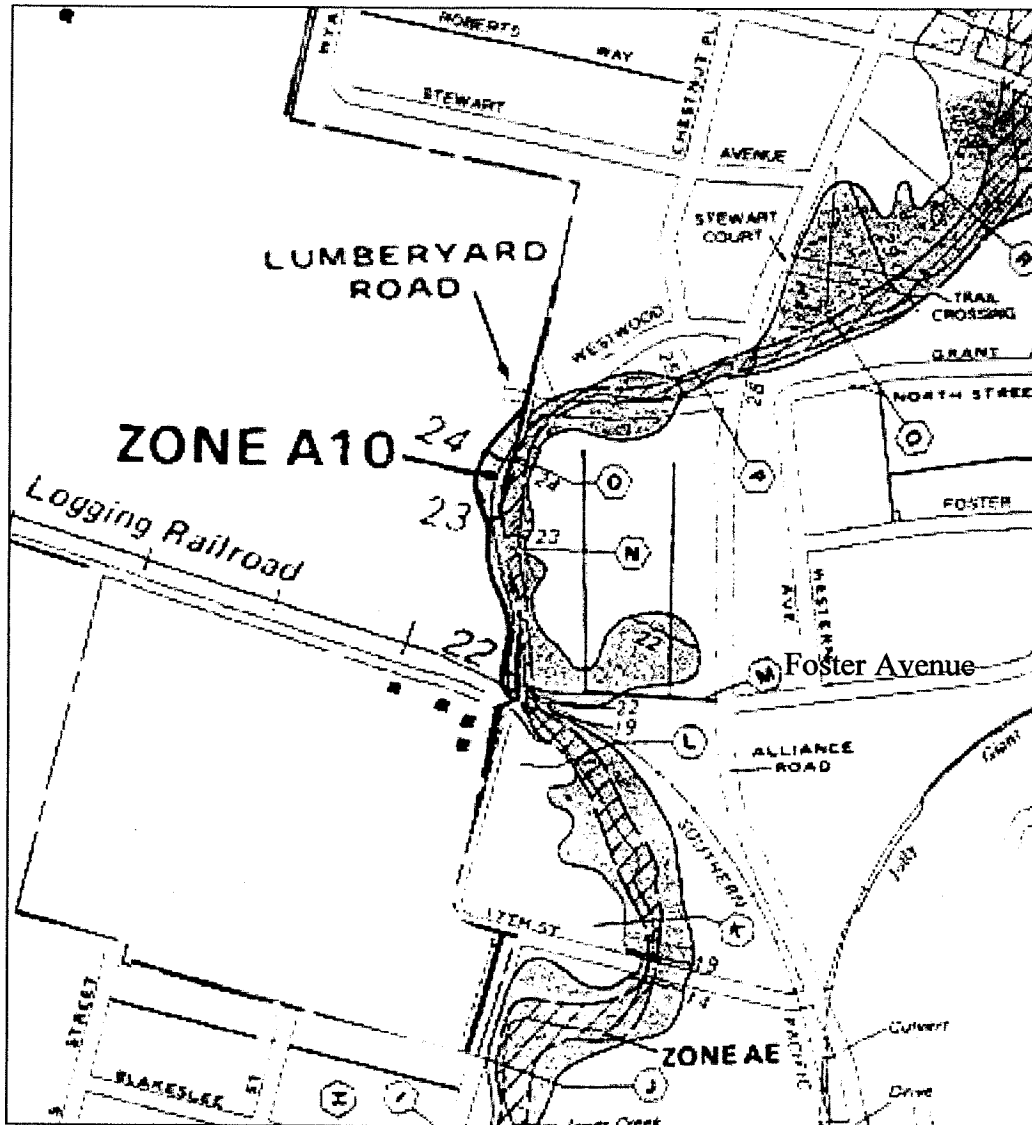


Figure 2. Section of FEMA County and City FIRM Map combined showing existing flooding conditions in the project area.

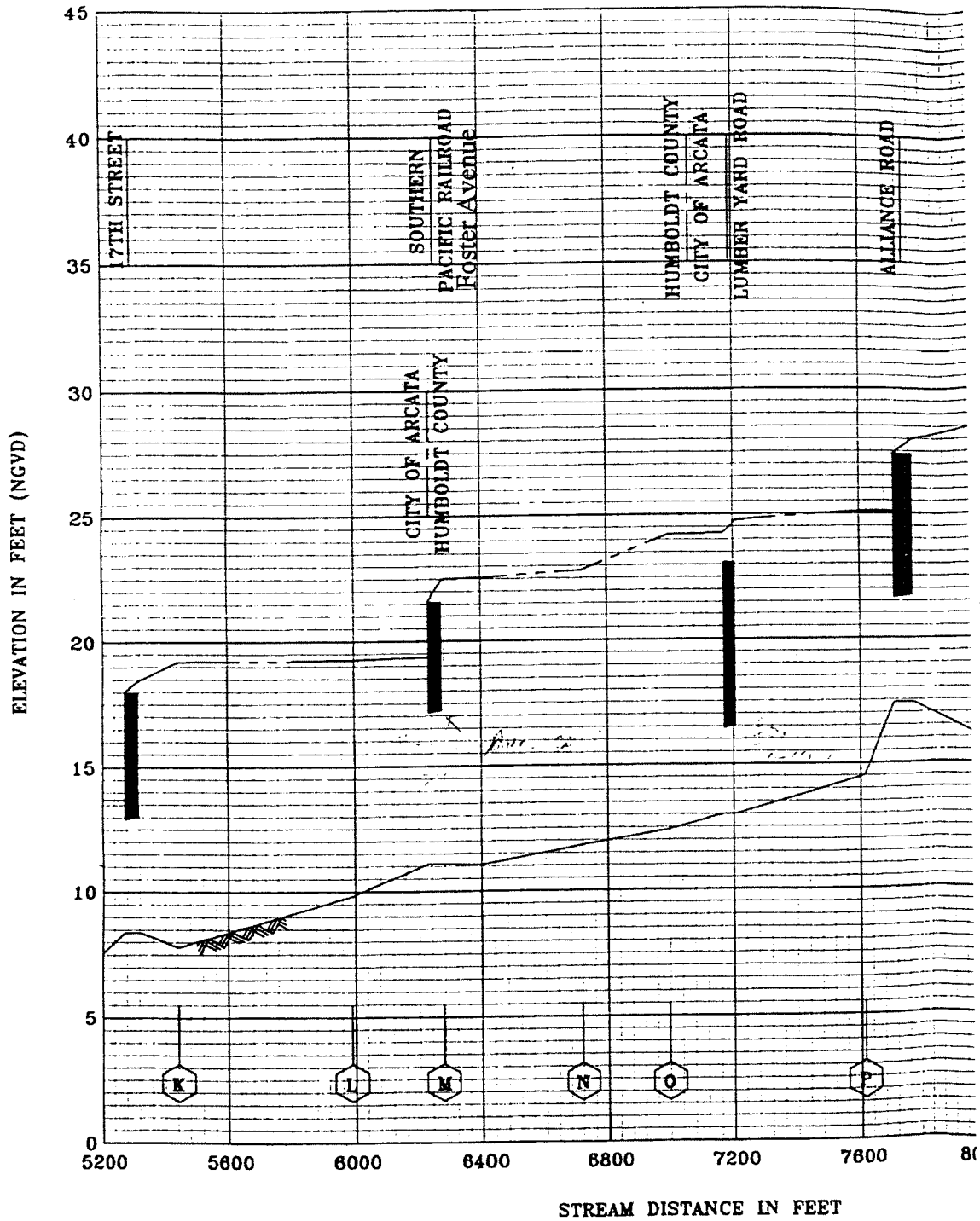


Figure 3. FEMA 100-year Flood Profile

An existing conditions profile from the HEC-RAS model is shown in Figure 4. While the HEC-RAS and the FEMA profile do not match exactly, they are similar (within approximately 0.3 feet). The model created from the surveyed data and observed Manning's roughness factors will provide a close approximation for the before and after comparison.

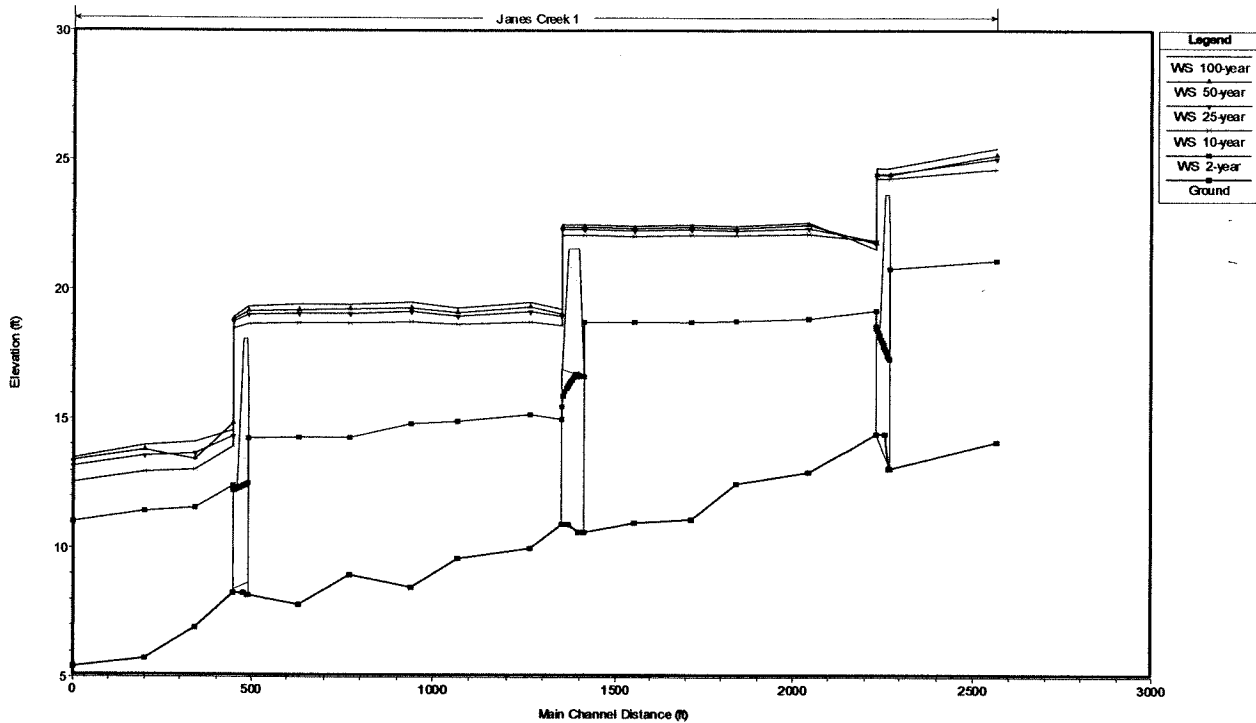


Figure 4. Existing conditions flood profile from HEC-RAS model

Table 2 below summarizes the existing condition water surface elevations and velocities for the 100-year and the 50-year flood profiles. The remaining run results for the 2-year, 10-year and 25-year can be found in the Appendix A of this report.

Table 2. Resulting Water Surface Elevations for the existing system model.

River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Velocity (fps)
2562.75	100-year	1030	25.43	2.81
2562.75	50-year	920	25.16	2.64
2252.9 Lumberyard Road				
2043.05	100-year	1030	22.57	5.19
2043.05	50-year	920	22.46	4.74
1553.05	100-year	1030	22.44	2.74
1553.05	50-year	920	22.35	2.48
1384.35 Foster Avenue				
1265.65	100-year	1030	19.52	6.88
1265.65	50-year	920	19.36	6.34
630.65	100-year	1030	19.4	2.68
630.65	50-year	920	19.25	2.48
470.325 17th Street				
340	100-year	1030	14.1	9.95
340	50-year	920	13.46	11.53

0	100-year	1030	13.5	6.97
0	50-year	920	13.4	6.45

Proposed Hydraulic Conditions

For the proposed condition, the existing culvert crossings at Foster Avenue and Lumberyard Road were replaced with arch-type CMP culverts and additional concrete box culverts when necessary. The culverts were sized to minimize the affects on the floodplain elevations in the vicinity of the crossings. While the existing survey shows a negative slope at the culvert crossings (most likely caused by sediment deposition), in the proposed condition model the culverts are given a flat slope to reflect probable conditions after installation. Additionally, an option of a clear span bridge was also modeled.

In order to reflect a range of future conditions in the creek a sensitivity analysis was performed with a range Manning’s n-values. The channel Manning’s n-value was left at 0.03 to reflect future conditions within the low flow channel that will not vary significantly from the existing conditions. The overbank Manning’s n-value were varied from 0.04 (to reflect a more cleared condition) to 0.08 (to reflect a more overgrown condition). Each of these models were then compared to the existing conditions model.

Proposed Conditions Model Results

The optimum configuration of culverts necessary at the Foster Road crossing was determined to be an arch with a span of 8 feet and a rise of 6 feet (at the bottom of the creek) with double box culverts 14 feet in width and 4 feet in height with an invert elevation of 18.8 feet. These culvert sizes will cause a slight decrease in water surface elevation upstream of Foster Road at the 100-year flow. The culverts are located at different elevations to provide a greater capacity during the larger events while minimizing the effects on the overall floodplain elevations. The road was raised to an elevation of 24 feet to take the road out of the 100-year floodplain. A cross section of the crossing at Foster Road and the proposed configuration of culverts is shown in Figure 6 below.

The optimum size culvert necessary at Lumberyard Road was determined to be an arch with a span of 10 feet and a rise of 5 feet. Again, this will cause a slight decrease in water surface elevation upstream of Lumberyard Road. The decrease in water surface elevation at the 100-year flow occurs in the direct vicinity of each crossing and is approximately 0.02 feet lower at Foster Avenue and 0.15 foot at Lumberyard Road. The resulting water surface profiles are shown below.

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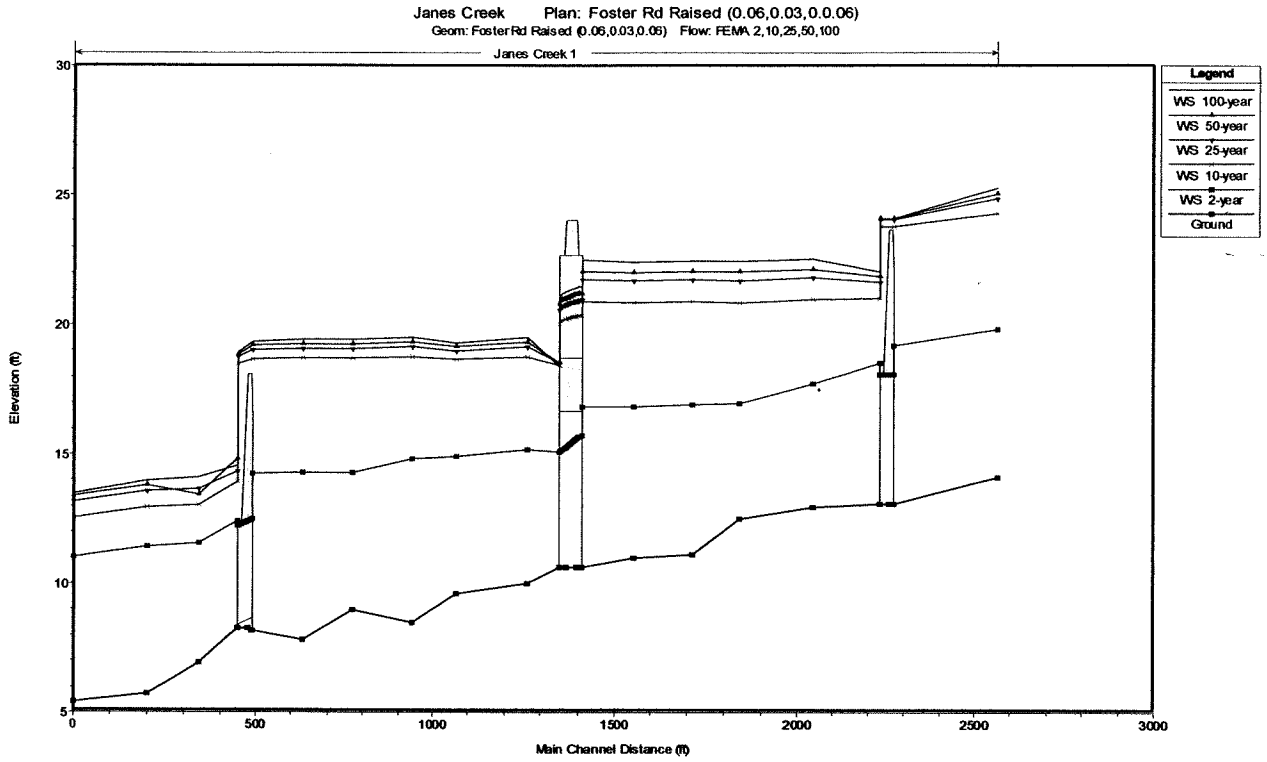


Figure 5. Resulting (proposed condition) Water Surface Profile

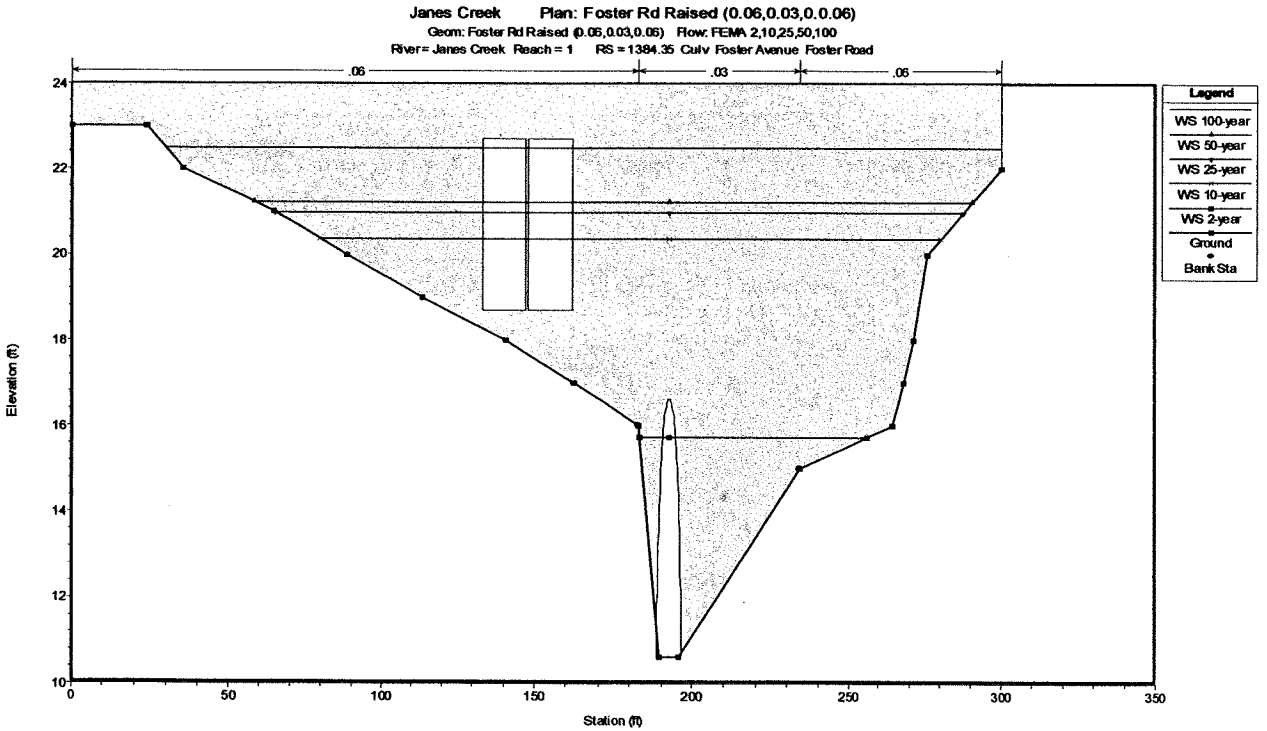


Figure 6. Proposed culverts at Foster Ave.

Proposed vs. Existing Conditions

The following table shows the difference in water surface elevations from the proposed condition to the existing condition for the 100-year, 50-year and 10-year flood profiles using Manning’s n-values of (0.06, 0.03, 0.06). The remaining run results for the 2-year and 25-year and results for the other Manning’s n-values modeled can be found in the Appendix A of this report. The differences between the water surface elevations under the varying n-value conditions is within a tenth of an foot. The largest difference occurs when the Manning’s n-value was lowered to 0.04 in the overbanks to reflect a cleared condition. To minimize the affects of the changes the overbanks should be maintained as close to existing conditions as possible.

Table 3. Resulting water surface elevations for the proposed culverts

River Sta	Profile	Q Total (cfs)	DIFF WSE (ft)
Manning’s N-values		(0.06,0.03,0.06)	
2562.75	100-year	1030	-0.15
2562.75	50-year	920	-0.1
2562.75	10-year	610	-0.35
2252.9 Lumberyard Road			
2043.05	100-year	1030	-0.02
2043.05	50-year	920	-0.3
2043.05	10-year	610	-1.15
1553.05	100-year	1030	-0.01
1553.05	50-year	920	-0.33
1553.05	10-year	610	-1.22
1384.35 Foster Avenue			
1265.65	100-year	1030	0
1265.65	50-year	920	-0.02
1265.65	10-year	610	0
630.65	100-year	1030	0
630.65	50-year	920	-0.02
630.65	10-year	610	0
470.325 17th Street			
340	100-year	1030	0
340	50-year	920	0
340	10-year	610	0
0	100-year	1030	0
0	50-year	920	0
0	10-year	610	0

Table 4 below shows the changes in velocity for the proposed culverts using various Manning’s n-values for the 100-year, 50-year and 10-year profiles. The remaining run results for the 2-year

and 25-year and results for the other Manning's n-values modeled can be found in the Appendix A of this report. As can be seen the differences in velocity are minimal at the higher flows.

Table 4. Resulting velocities for the proposed culverts using a range of Manning's n-values

River Sta	Profile	Q Total (cfs)	DIFF VEL (ft/sec)
Manning's N-values		(0.06,0.03,0.06)	
2562.75	100-year	1030	0.08
2562.75	50-year	920	0.05
2562.75	10-year	610	0.15
2252.9 Lumberyard Road			
2043.05	100-year	1030	0.01
2043.05	50-year	920	0.31
2043.05	10-year	610	1.04
1553.05			
1553.05	100-year	1030	0
1553.05	50-year	920	0.14
1553.05	10-year	610	0.43
1384.35 Foster Avenue			
1265.65	100-year	1030	0
1265.65	50-year	920	0.02
1265.65	10-year	610	0
630.65			
630.65	100-year	1030	0
630.65	50-year	920	0
630.65	10-year	610	0
470.325 17th Street			
340	100-year	1030	0
340	50-year	920	0
340	10-year	610	0
0			
0	100-year	1030	0
0	50-year	920	0
0	10-year	610	0

The proposed changes at each of the crossings (Foster Road and Lumberyard Road) had no affect on the water surface elevation at 17th Street. The water surface elevation at 17th Street is controlled only by downstream structures. In order for upstream features to change the profile at 17th Street, a change in flow rate would have to occur. Based on the results of the before and after improvements analysis the flood levels match closely and therefore there will not be a measurable change in associated flow rates.

For the lower flows (2-year and below) water surface elevations are lower with the new culverts due to the wider cross section at the bottom of the arches. In either case the flow is contained within the channel. The results for the 2-year profile can be found in Appendix A.

Clear Span Bridge Results

The option of replacing the existing culverts with clear span bridges resulted in raising the water surface profile by approximately 0.5 feet for the 100-year flood profile upstream of the Lumberyard crossing and lowering the water surface elevation by approximately 1 foot through the project reach upstream of Foster Avenue. These are significantly greater differences than the arch culvert option and may result in measurable changes in the flow rate at 17th Street. Tables 5 and 6 below show the differences in water surface elevation and velocity for the 100-year, 50-year and 10-year profiles using a Manning's n-values of (0.06, 0.03, 0.06). The remaining run results for the 2-year and 25-year and results for the other Manning's n-values modeled can be found in the Appendix A of this report. The resulting profile using the existing system Manning's n-values (0.06, 0.03, 0.06) is shown below.

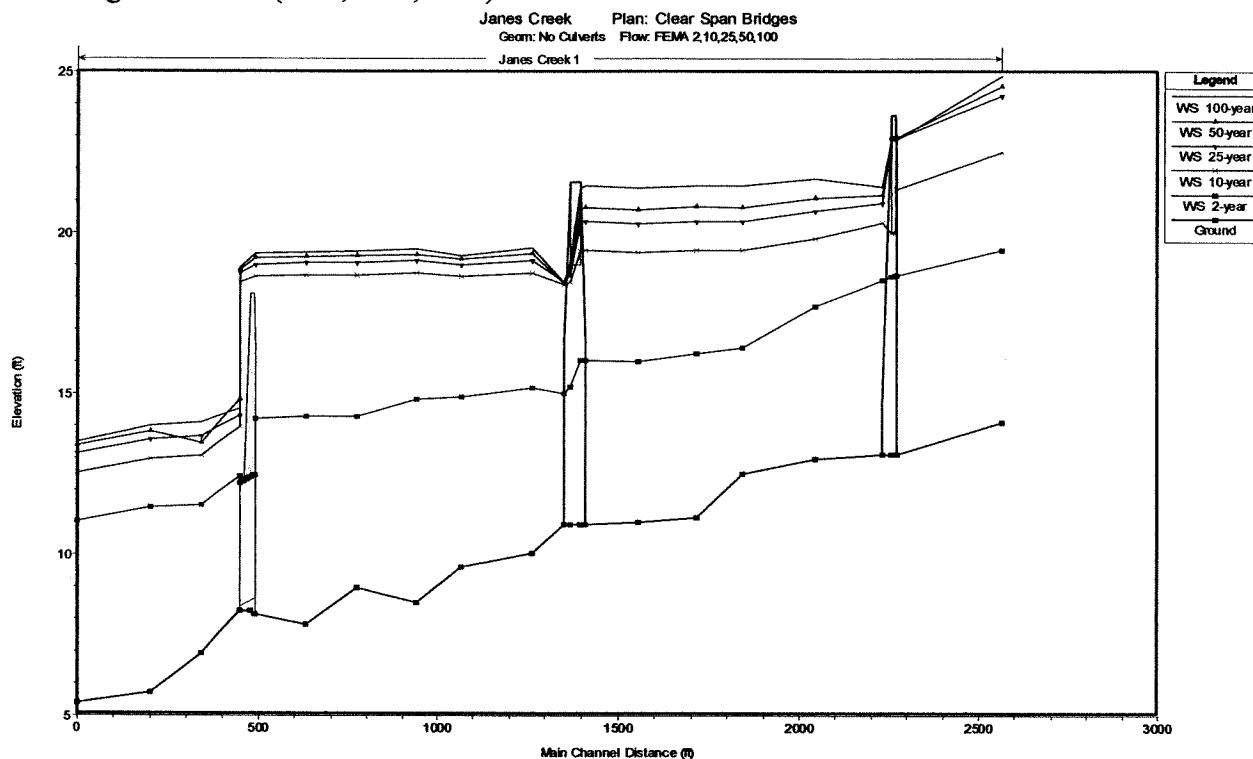


Figure 7. Clear Span Bridge Option

Table 5. Resulting water surface elevations for the clear span bridge option using a range of Manning's n-values

River Sta	Profile	Q Total (cfs)	DIFF WSE (ft)
Manning's N-values		(0.06,0.03,0.06)	
2562.75	100-year	1030	-0.56
2562.75	50-year	920	-0.61
2562.75	10-year	610	-2.16
2252.9 Lumberyard Road			
2043.05	100-year	1030	-0.9
2043.05	50-year	920	-1.38
2043.05	10-year	610	-2.32
1553.05	100-year	1030	-1.05
1553.05	50-year	920	-1.62
1553.05	10-year	610	-2.67
1384.35 Foster Avenue			
1265.65	100-year	1030	0
1265.65	50-year	920	0
1265.65	10-year	610	0
630.65	100-year	1030	0
630.65	50-year	920	0.01
630.65	10-year	610	0
470.325 17th Street			
340	100-year	1030	0
340	50-year	920	0
340	10-year	610	0
0	100-year	1030	0
0	50-year	920	0
0	10-year	610	0

Table 6. Resulting velocities for the clear span bridge option using a range of Manning's n-values

River Sta	Profile	Q Total (cfs)	DIFF VEL (ft/sec)
Manning's N-values		(0.06,0.03,0.06)	
2562.75	100-year	1030	0.32
2562.75	50-year	920	0.34
2562.75	10-year	610	1.21
2252.9 Lumberyard Road			
2043.05	100-year	1030	1.13
2043.05	50-year	920	1.76
2043.05	10-year	610	2.7

1553.05	100-year	1030	0.55
1553.05	50-year	920	0.85
1553.05	10-year	610	1.19
1384.35 Foster Avenue			
1265.65	100-year	1030	0
1265.65	50-year	920	-0.01
1265.65	10-year	610	0
630.65	100-year	1030	0
630.65	50-year	920	-0.01
630.65	10-year	610	0
470.325 17th Street			
340	100-year	1030	0
340	50-year	920	0
340	10-year	610	0
0	100-year	1030	0
0	50-year	920	0
0	10-year	610	0

Conclusion

The proposed changes at the Lumberyard Road and Foster Avenue culvert crossings would result in minimal changes to the existing floodplain elevations. Changes in water surface elevation would occur only in the direct vicinity and upstream of the crossings. The proposed changes made at either the Lumberyard Road or the Foster Avenue crossing would have no affect on the 17th Street crossing.

Appendix A – Results for all Flood Profiles

Table A-1. Resulting Water Surface Elevations for the existing system model.

River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Velocity (fps)
2562.75	100-year	1030	25.43	2.81
2562.75	50-year	920	25.16	2.64
2562.75	25-year	825	25.00	2.44
2562.75	10-year	610	24.65	1.93
2562.75	2-year	275	21.03	2.11

2252.9 Lumberyard Road

2043.05	100-year	1030	22.57	5.19
2043.05	50-year	920	22.46	4.74
2043.05	25-year	825	22.37	4.33
2043.05	10-year	610	22.13	3.38
2043.05	2-year	275	18.89	3.67
1553.05	100-year	1030	22.44	2.74
1553.05	50-year	920	22.35	2.48
1553.05	25-year	825	22.28	2.25
1553.05	10-year	610	22.07	1.73
1553.05	2-year	275	18.75	1.54

1384.35 Foster Avenue

1265.65	100-year	1030	19.52	6.88
1265.65	50-year	920	19.36	6.34
1265.65	25-year	825	19.16	5.91
1265.65	10-year	610	18.76	4.71
1265.65	2-year	275	15.16	4.7
630.65	100-year	1030	19.4	2.68
630.65	50-year	920	19.25	2.48
630.65	25-year	825	19.06	2.32
630.65	10-year	610	18.68	1.87
630.65	2-year	275	14.29	3.52

470.325 17th Street

340	100-year	1030	14.1	9.95
340	50-year	920	13.46	11.53
340	25-year	825	13.67	9.49

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340	10-year	610	13.06	9
340	2-year	275	11.55	7.13
0	100-year	1030	13.5	6.97
0	50-year	920	13.4	6.45
0	25-year	825	13.16	6.3
0	10-year	610	12.54	5.9
0	2-year	275	11.04	4.86

Table A-2. Resulting water surface elevations for the proposed culverts using a range of Manning's n-values

River Sta	Profile	Q Total (cfs)	EXISTING WSE (ft)	Proposed WSE (ft)	DIFF WSE (ft)	Proposed WSE (ft)	DIFF WSE (ft)	Proposed WSE (ft)	DIFF WSE (ft)
Manning's N-values				(0.06,0.03,0.06)		(0.08,0.03,0.08)		(0.04,0.03,0.04)	
2562.75	100-year	1030	25.43	25.28	-0.15	25.3	-0.13	25.2	-0.23
2562.75	50-year	920	25.16	25.06	-0.1	25.08	-0.08	25.01	-0.15
2562.75	25-year	825	25	24.85	-0.15	24.87	-0.13	24.82	-0.18
2562.75	10-year	610	24.65	24.3	-0.35	24.32	-0.33	24.28	-0.37
2562.75	2-year	275	21.03	19.82	-1.21	19.82	-1.21	19.82	-1.21
2252.9 Lumberyard Road									
2043.05	100-year	1030	22.57	22.55	-0.02	22.6	0.03	22.49	-0.08
2043.05	50-year	920	22.46	22.16	-0.3	22.19	-0.27	22.14	-0.32
2043.05	25-year	825	22.37	21.83	-0.54	21.85	-0.52	21.79	-0.58
2043.05	10-year	610	22.13	20.98	-1.15	21	-1.13	20.97	-1.16
2043.05	2-year	275	18.89	17.73	-1.16	17.74	-1.15	17.71	-1.18
1553.05	100-year	1030	22.44	22.43	-0.01	22.48	0.04	22.36	-0.08
1553.05	50-year	920	22.35	22.02	-0.33	22.06	-0.29	22	-0.35
1553.05	25-year	825	22.28	21.69	-0.59	21.72	-0.56	21.66	-0.62
1553.05	10-year	610	22.07	20.85	-1.22	20.87	-1.2	20.83	-1.24
1553.05	2-year	275	18.75	16.81	-1.94	16.86	-1.89	16.74	-2.01
1384.35 Foster Avenue									
1265.65	100-year	1030	19.52	19.52	0	19.56	0.04	19.47	-0.05
1265.65	50-year	920	19.36	19.34	-0.02	19.38	0.02	19.32	-0.04
1265.65	25-year	825	19.16	19.16	0	19.19	0.03	19.12	-0.04
1265.65	10-year	610	18.76	18.76	0	18.78	0.02	18.73	-0.03
1265.65	2-year	275	15.16	15.16	0	15.22	0.06	15.07	-0.09
630.65	100-year	1030	19.4	19.4	0	19.39	-0.01	19.41	0.01
630.65	50-year	920	19.25	19.23	-0.02	19.22	-0.03	19.26	0.01
630.65	25-year	825	19.06	19.06	0	19.05	-0.01	19.06	0

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630.65	10-year	610	18.68	18.68	0	18.68	0	18.69	0.01
630.65	2-year	275	14.29	14.29	0	14.27	-0.02	14.31	0.02
470.325 17th Street									
340	100-year	1030	14.1	14.1	0	14.1	0	14.1	0
340	50-year	920	13.46	13.46	0	13.46	0	13.46	0
340	25-year	825	13.67	13.67	0	13.67	0	13.67	0
340	10-year	610	13.06	13.06	0	13.06	0	13.06	0
340	2-year	275	11.55	11.55	0	11.55	0	11.55	0
0	100-year	1030	13.5	13.5	0	13.5	0	13.5	0
0	50-year	920	13.4	13.4	0	13.4	0	13.4	0
0	25-year	825	13.16	13.16	0	13.16	0	13.16	0
0	10-year	610	12.54	12.54	0	12.54	0	12.54	0
0	2-year	275	11.04	11.04	0	11.04	0	11.04	0

Table A-3. Resulting velocities for the proposed culverts using a range of Manning's n-values

River Sta	Profile	Q Total (cfs)	EXISTING VEL (fps)	Proposed VEL (fps)	DIFF VEL (fps)	Proposed VEL (fps)	DIFF VEL (fps)	Proposed VEL (fps)	DIFF VEL (fps)
			Manning's N-values			(0.06,0.03,0.06)		(0.08,0.03,0.08)	
								(0.04,0.03,0.04)	
2562.75	100-year	1030	2.81	2.89	0.08	2.87	0.06	2.93	0.12
2562.75	50-year	920	2.64	2.69	0.05	2.68	0.04	2.72	0.08
2562.75	25-year	825	2.44	2.51	0.07	2.51	0.07	2.53	0.09
2562.75	10-year	610	1.93	2.08	0.15	2.07	0.14	2.09	0.16
2562.75	2-year	275	2.11	3.14	1.03	3.14	1.03	3.14	1.03
2252.9 Lumberyard Road									
2043.05	100-year	1030	5.19	5.2	0.01	5.16	-0.03	5.27	0.08
2043.05	50-year	920	4.74	5.05	0.31	5.02	0.28	5.08	0.34
2043.05	25-year	825	4.33	4.88	0.55	4.85	0.52	4.92	0.59
2043.05	10-year	610	3.38	4.42	1.04	4.4	1.02	4.43	1.05
2043.05	2-year	275	3.67	5.73	2.06	5.7	2.03	5.76	2.09
1553.05	100-year	1030	2.74	2.74	0	2.72	-0.02	2.77	0.03
1553.05	50-year	920	2.48	2.62	0.14	2.6	0.12	2.63	0.15
1553.05	25-year	825	2.25	2.49	0.24	2.48	0.23	2.51	0.26
1553.05	10-year	610	1.73	2.16	0.43	2.15	0.42	2.16	0.43
1553.05	2-year	275	1.54	2.65	1.11	2.61	1.07	2.71	1.17
1384.35 Foster Avenue									
1265.65	100-year	1030	6.88	6.88	0	7.54	0.66	5.86	-1.02

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1265.65	50-year	920	6.34	6.36	0.02	6.95	0.61	5.41	-0.93
1265.65	25-year	825	5.91	5.91	0	6.45	0.54	5.07	-0.84
1265.65	10-year	610	4.71	4.71	0	5.12	0.41	4.06	-0.65
1265.65	2-year	275	4.7	4.7	0	4.8	0.1	4.53	-0.17
630.65	100-year	1030	2.68	2.68	0	3.26	0.58	1.98	-0.7
630.65	50-year	920	2.48	2.48	0	3.01	0.53	1.83	-0.65
630.65	25-year	825	2.32	2.32	0	2.81	0.49	1.72	-0.6
630.65	10-year	610	1.87	1.87	0	2.25	0.38	1.4	-0.47
630.65	2-year	275	3.52	3.52	0	3.79	0.27	3.09	-0.43

470.325 17th Street

340	100-year	1030	9.95	9.95	0	9.95	0	9.95	0
340	50-year	920	11.53	11.53	0	11.53	0	11.53	0
340	25-year	825	9.49	9.49	0	9.49	0	9.49	0
340	10-year	610	9	9	0	9	0	9	0
340	2-year	275	7.13	7.13	0	7.13	0	7.13	0
0	100-year	1030	6.97	6.97	0	6.97	0	6.97	0
0	50-year	920	6.45	6.45	0	6.45	0	6.45	0
0	25-year	825	6.3	6.3	0	6.3	0	6.3	0
0	10-year	610	5.9	5.9	0	5.9	0	5.9	0
0	2-year	275	4.86	4.86	0	4.86	0	4.86	0

Table A-4. Resulting water surface elevations for the clear span bridge option using a range of Manning's n-values

River Sta	Profile	Q Total (cfs)	EXISTING WSE (ft)	Proposed WSE (ft)	DIFF WSE (ft)	Proposed WSE (ft)	DIFF WSE (ft)	Proposed WSE (ft)	DIFF WSE (ft)
Manning's N-values				(0.06,0.03,0.06)		(0.08,0.03,0.08)		(0.04,0.03,0.04)	
2562.75	100-year	1030	25.43	24.87	-0.56	24.84	-0.59	24.84	-0.59
2562.75	50-year	920	25.16	24.55	-0.61	24.53	-0.63	24.53	-0.63
2562.75	25-year	825	25	24.24	-0.76	24.22	-0.78	24.22	-0.78
2562.75	10-year	610	24.65	22.49	-2.16	22.48	-2.17	22.47	-2.18
2562.75	2-year	275	21.03	19.46	-1.57	19.46	-1.57	19.46	-1.57
2252.9 Lumberyard Road									
2043.05	100-year	1030	22.57	21.67	-0.9	21.3	-1.27	21.47	-1.1
2043.05	50-year	920	22.46	21.08	-1.38	20.92	-1.54	20.94	-1.52
2043.05	25-year	825	22.37	20.67	-1.7	20.56	-1.81	20.54	-1.83
2043.05	10-year	610	22.13	19.81	-2.32	19.78	-2.35	19.73	-2.4
2043.05	2-year	275	18.89	17.73	-1.16	17.72	-1.17	17.74	-1.15
1553.05	100-year	1030	22.44	21.39	-1.05	20.91	-1.53	21.14	-1.3

Foster Avenue Development Hydraulic Analysis

1553.05	50-year	920	22.35	20.73	-1.62	20.5	-1.85	20.54	-1.81
1553.05	25-year	825	22.28	20.28	-2	20.13	-2.15	20.09	-2.19
1553.05	10-year	610	22.07	19.4	-2.67	19.35	-2.72	19.27	-2.8
1553.05	2-year	275	18.75	16.01	-2.74	16.07	-2.68	15.95	-2.8

1384.35 Foster Avenue

1265.65	100-year	1030	19.52	19.52	0	19.56	0.04	19.47	-0.05
1265.65	50-year	920	19.36	19.36	0	19.39	0.03	19.32	-0.04
1265.65	25-year	825	19.16	19.16	0	19.19	0.03	19.12	-0.04
1265.65	10-year	610	18.76	18.76	0	18.78	0.02	18.73	-0.03
1265.65	2-year	275	15.16	15.16	0	15.22	0.06	15.07	-0.09

630.65	100-year	1030	19.4	19.4	0	19.39	-0.01	19.41	0.01
630.65	50-year	920	19.25	19.26	0.01	19.25	0	19.26	0.01
630.65	25-year	825	19.06	19.06	0	19.05	-0.01	19.06	0
630.65	10-year	610	18.68	18.68	0	18.68	0	18.69	0.01
630.65	2-year	275	14.29	14.29	0	14.27	-0.02	14.31	0.02

470.325 17th Street

340	100-year	1030	14.1	14.1	0	14.1	0	14.1	0
340	50-year	920	13.46	13.46	0	13.46	0	13.46	0
340	25-year	825	13.67	13.67	0	13.67	0	13.67	0
340	10-year	610	13.06	13.06	0	13.06	0	13.06	0
340	2-year	275	11.55	11.55	0	11.55	0	11.55	0
0	100-year	1030	13.5	13.5	0	13.5	0	13.5	0
0	50-year	920	13.4	13.4	0	13.4	0	13.4	0
0	25-year	825	13.16	13.16	0	13.16	0	13.16	0
0	10-year	610	12.54	12.54	0	12.54	0	12.54	0
0	2-year	275	11.04	11.04	0	11.04	0	11.04	0

Table A-5. Resulting velocities for the clear span bridge option using a range of Manning's n-values

River Sta	Profile	Q Total (cfs)	EXISTING VEL (fps)	Proposed VEL (fps)	DIFF VEL (fps)	Proposed VEL (fps)	DIFF VEL (fps)	Proposed VEL (fps)	DIFF VEL (fps)			
				Manning's N-values								
				(0.06,0.03,0.06)			(0.08,0.03,0.08)			(0.04,0.03,0.04)		
2562.75	100-year	1030	2.81	3.13	0.32	3.15	0.34	3.15	0.34			
2562.75	50-year	920	2.64	2.98	0.34	2.99	0.35	2.99	0.35			
2562.75	25-year	825	2.44	2.85	0.41	2.86	0.42	2.87	0.43			
2562.75	10-year	610	1.93	3.14	1.21	3.15	1.22	3.16	1.23			
2562.75	2-year	275	2.11	3.6	1.49	3.6	1.49	3.6	1.49			

2252.9 Lumberyard Road

Foster Avenue Development Hydraulic Analysis

2043.05	100-year	1030	5.19	6.32	1.13	6.9	1.71	6.61	1.42
2043.05	50-year	920	4.74	6.5	1.76	6.77	2.03	6.73	1.99
2043.05	25-year	825	4.33	6.48	2.15	6.67	2.34	6.7	2.37
2043.05	10-year	610	3.38	6.08	2.7	6.14	2.76	6.23	2.85
2043.05	2-year	275	3.67	5.72	2.05	5.74	2.07	5.7	2.03

1553.05	100-year	1030	2.74	3.29	0.55	3.6	0.86	3.44	0.7
1553.05	50-year	920	2.48	3.33	0.85	3.48	1	3.46	0.98
1553.05	25-year	825	2.25	3.27	1.02	3.38	1.13	3.4	1.15
1553.05	10-year	610	1.73	2.92	1.19	2.96	1.23	3.01	1.28
1553.05	2-year	275	1.54	3.5	1.96	3.43	1.89	3.58	2.04

1384.35 Foster Avenue

1265.65	100-year	1030	6.88	6.88	0	7.54	0.66	5.86	-1.02
1265.65	50-year	920	6.34	6.33	-0.01	6.93	0.59	5.41	-0.93
1265.65	25-year	825	5.91	5.91	0	6.45	0.54	5.07	-0.84
1265.65	10-year	610	4.71	4.71	0	5.12	0.41	4.06	-0.65
1265.65	2-year	275	4.7	4.7	0	4.8	0.1	4.53	-0.17

630.65	100-year	1030	2.68	2.68	0	3.26	0.58	1.98	-0.7
630.65	50-year	920	2.48	2.47	-0.01	3	0.52	1.83	-0.65
630.65	25-year	825	2.32	2.32	0	2.81	0.49	1.72	-0.6
630.65	10-year	610	1.87	1.87	0	2.25	0.38	1.4	-0.47
630.65	2-year	275	3.52	3.52	0	3.79	0.27	3.09	-0.43

470.325 17th Street

340	100-year	1030	9.95	9.95	0	9.95	0	9.95	0
340	50-year	920	11.53	11.53	0	11.53	0	11.53	0
340	25-year	825	9.49	9.49	0	9.49	0	9.49	0
340	10-year	610	9	9	0	9	0	9	0
340	2-year	275	7.13	7.12	-0.01	7.12	-0.01	7.12	-0.01

0	100-year	1030	6.97	6.97	0	6.97	0	6.97	0
0	50-year	920	6.45	6.45	0	6.45	0	6.45	0
0	25-year	825	6.3	6.3	0	6.3	0	6.3	0
0	10-year	610	5.9	5.9	0	5.9	0	5.9	0
0	2-year	275	4.86	4.86	0	4.86	0	4.86	0