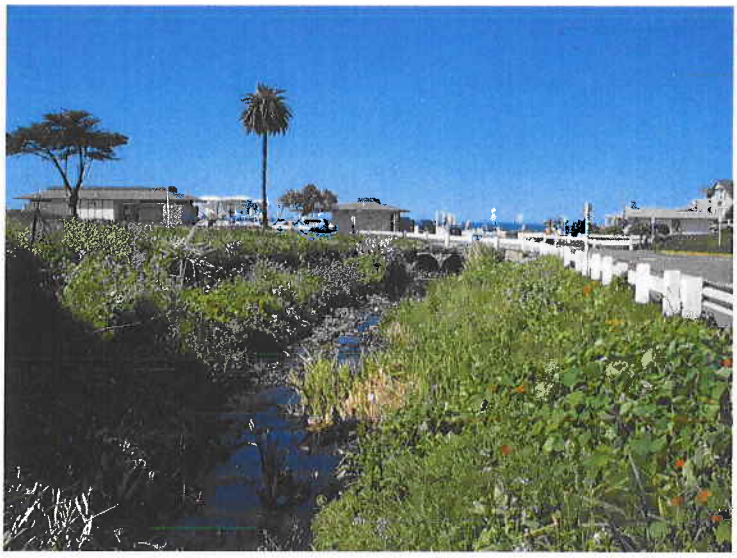
COTTONWOOD CREEK/MOONLIGHT BEACH



Hydrology and Facilities Analysis Summary

Prepared for:

CITY OF ENCINITAS

Prepared By:

NOLTE ASSOCIATES, INC.

April 9, 2003

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1.0 INTRODUCTION

The study area is in an urbanized location within the coastal plain of San Diego County in the City of Encinitas. The Cottonwood Creek watershed is bound by the Pacific Ocean to the west, Leucadia on the north, Cardiff on the south, and La Costa South on the east. The watershed drains westerly along Encinitas Boulevard through a series of storm drain pipes, natural channels, and streets until reaching Moonlight Beach.

This Hydrology and Facilities Analysis report for the Cottonwood Creek/Moonlight Beach area will briefly summarize our results up to this point.

2.0 HYDROLOGIC ANALYSIS

We have performed 3 separate analyses to help us determine what methodology fits best for the Cottonwood Creek watershed. Methodologies we used include the Modified Rational Method, the SCS Unit Hydrograph Method, and a combination to these two methods (Rational Method up to 640 acres then switch over to Unit Hydrograph Method). The results of these analyses allow us to bracket the upper and lower limits of peak flow rates.

We performed field reconnaissance on September 24 and 25, 2002. Watershed boundaries specified in the City of Encinitas' Master Drainage Plan were verified and revised accordingly. A 1"=800' scale street flow map provided by the City of Encinitas was also used in the determination and verification of the watershed boundaries. Existing land uses were also confirmed during these site visits.

We divided the watershed into subareas based on land use, soil type, topography, and critical flow locations. These critical flow locations include the large detention basin located near Quail Gardens Drive in the northeast corner of the watershed and the area from Highway 101 to the ocean outfall at Moonlight Beach. Our analysis includes the outflow of approximately 500 cubic feet per second (cfs) (SB&O Detention and Water Quality Basin Report dated February 16, 2001) from the detention basin that captures storm runoff from the 316-acre development. However, to generate 500 cfs while keeping the time of concentration at the approximate value listed in the SB&O report, land use and soil classification values may not be indicative of the actual site conditions in this area.

Table 1 summarizes the results from the three methods described above in addition to the results presented in the City of Encinitas Master Plan of Drainage (1992).

Table 1: Summary of Hydrologic R

Master Plan of Drainage (1992)			ated Method	Location
Node #	Q_{100} (cfs)	Area	Area (AC)	
2006	380	1	172.4	Encinitas Blvd @ Princehouse Lane
2009	790	3	287.5	Encinitas Blvd @ Delphinium St.
2015	1500	4	804.5	Encinitas Blvd @ Quail Rd
2018	2200	1	1318.2	Encinitas Blvd @ West side I-5 ramps
2607	3250	1	2091.9	B St. @ 4th St.

[1] Discrepancy in areas due to rounding

3.0 STORM DRAIN FACILITIES ANALYSIS

3.1 Existing Conditions

Using the results from the Unit Hydrograph analysis, the ocean outfall pipes, culverts, and natural channels within the Moonlight Beach/Cottonwood Creek area were evaluated for their hydraulic capacity. Based on the Hydrology and Water Quality Report for Cottonwood Creek (prepared by Nolte Associates, Inc. dated January 2003), approximately 960 cfs from Cottonwood Creek is captured by the existing 96-inch culvert on the eastern side of Vulcan Avenue. This flow confluences with the 204 cfs inflow near Second Avenue. The combined flow of 1164 cfs was used as the design discharge to analyze the Third Street culvert crossing and the channel capacity upstream of Third Street. Near Fourth Street, an additional 90 cfs joins the creek which increases the design flow to 1254 cfs just upstream of the culverts that pass under B Street.

As-built plans and topographic information provided by the City of Encinitas and an additional site visit conducted on March 30, 2003, were used to determine existing hydraulic parameters for the storm drain facilities west of Pacific Coast Highway (PCH). Figure 1 illustrates the various channels and structures along this reach of Cottonwood Creek.

Based on topographic information provided by the City of Encinitas, we assumed a slope of 1.5% for the natural channel sections in the study reach. From our site visit, we determined that the channel roughness coefficients ranged from 0.03 to 0.05. Natural channels designated A, B, and D on Figure 1 all have the capacity to convey the design discharge value within their banks. However, natural channel C, located near the entrance to the 10' x 4' RCB and the triple 6'-8" x 5' CMPA flows at a depth of 7.4 feet. This is approximately 2.4 feet above the right overbank. Channel capacity has been constricted by the deposition of sediment caused by backwater from the downstream culverts. The velocities in all of the natural channels range in value from 7.9 fps to 12.3 fps (see Table 2). These high velocities will erode the channel and overbanks, in addition to uprooting smaller trees. To maintain the integrity of the channel and reduce velocities, two solutions have been proposed in Section 3.2.

Our evaluation of the 6' x 4' double box culvert under Third Street showed that the design discharge of 1164 cfs could theoretically reach a depth of 21.7 feet, approximately 13.7 feet above the headwall. In Section 3.2, alternatives to this culvert are discussed.

Downstream from the 6' x 4' double box culvert, there are two sets of culverts, a 10' x 4' RCB and a triple 6'-8" x 5' CMPA, that pass under B Street. To determine the discharge captured by the 10' x 4' RCB near Fourth Street, we determined the maximum amount of flow that enters the triple 6'-8" x 5' CMPA without spilling over the headwall. This value was estimated to be 750 cfs, with the remaining 504 cfs captured by the 10' x 4' RCB. Using this discharge value and a slope of 1.5%, the depth of flow at the upstream end of the 10' x 4' RCB is 8.2 feet. This is

approximately 2.2 feet above the headwall. Alternatives to prevent flooding at this location are discussed in Section 3.2.

Lastly, we looked at the 60-inch and 48-inch RCPs that discharge into the ocean. Based on a slope of 1.5% and a flow value of 504 cfs, we determined that the depth of flow is approximately 8.2 feet. This is roughly 3 feet above the top of the 60-inch pipe. Alternatives to these RCPs are discussed in the next section.

See Table 2 and Appendix A and B for a summary of the existing hydraulic conditions.

3.2 Proposed Alternatives

Natural Channel Sections

Sediment deposition and high velocities are eroding the channel and reducing its ability to convey the design discharge. The following two solutions propose to alleviate these problems:

Solution A: With a regular maintenance program, channel section C should be restored to the dimensions similar to those that are present upstream in channel section B. It would then be able to adequately handle the design flow.

Solution B: One alternative to reduce the velocities (7.9 fps to 12.3 fps) and protect the channel would be to construct drop structures or grade control structures at several locations along the creek.

Third Street Crossing

Three alternatives to the 6' x 4' double box culvert under Third Street were evaluated to convey 1164 cfs at a slope of 2.4%. The alternatives are listed below and are summarized in Table 3. Hydraulic calculations for these alternatives can be found in Appendix C.

Alternative A: 3-7' x 5' RCB with 3' headwall
Alternative B: 2-6' x 4' RCB and 1-10' x 4' RCB
Alternative C: 24' x 6' Conspan Bridge

B Street Crossing

We determined the values of the flow split using different criteria than under the existing conditions. We limited the headwater elevation at the triple 6'-8" x 5' CMPA to the top of the culvert (ignoring the headwall). Under this assumption, the flow entering the culvert would be approximately 580 cfs. The remaining 674 cfs would then enter the existing 10' x 4' RCB.

Two alternatives to the 10' x 4' RCB that pass under B Street were proposed to convey 674 cfs at a slope of 1.5%. The alternatives are listed below and are summarized in Table 3. Hydraulic calculations for these alternatives can be found in Appendix C.

Alternative A: 3-10' x 4' RCB with 2' headwall
Alternative B: 20' x 5' Conspan Bridge

Ocean Outfall

Three alternatives to the 60-inch and 48-inch RCPs that convey 580 cfs to the ocean under the volleyball courts were proposed. The alternatives are listed below and are summarized in Table 3. Hydraulic calculations for these alternatives can be found in Appendix C.

Alternative A: 3-6' x 5' RCB with 1.5' headwall
Alternative B: 16' x 5' Conspan Bridge
Alternative C: 2- 60" RCP and 48" RCP

3.3 Proposed Fourth Street Storm Drain System

During a significant storm event, runoff has historically ponded at the intersection of Fourth Street and A Street before cascading southerly down Fourth Street to Cottonwood Creek. This area has become a safety hazard due to the quantity and velocity of the water as it sheet flows down Fourth Street. One alternative that has been discussed with the City is to construct several curb inlets along Fourth Street immediately south of its intersection with A Street (just before runoff is conveyed down the hill). Using our Rational Method study, we determined that the contributing flow to this point from all upstream areas is approximately 100 cfs. We have sized the inlets assuming 100% capture. If each inlet captures 50 cfs, two 65-foot inlets are needed.

Assuming a slope of 11.3%, a 36-inch storm drain pipe is required to convey 100 cfs. A length has not been specified due to the unknown tie-in location.

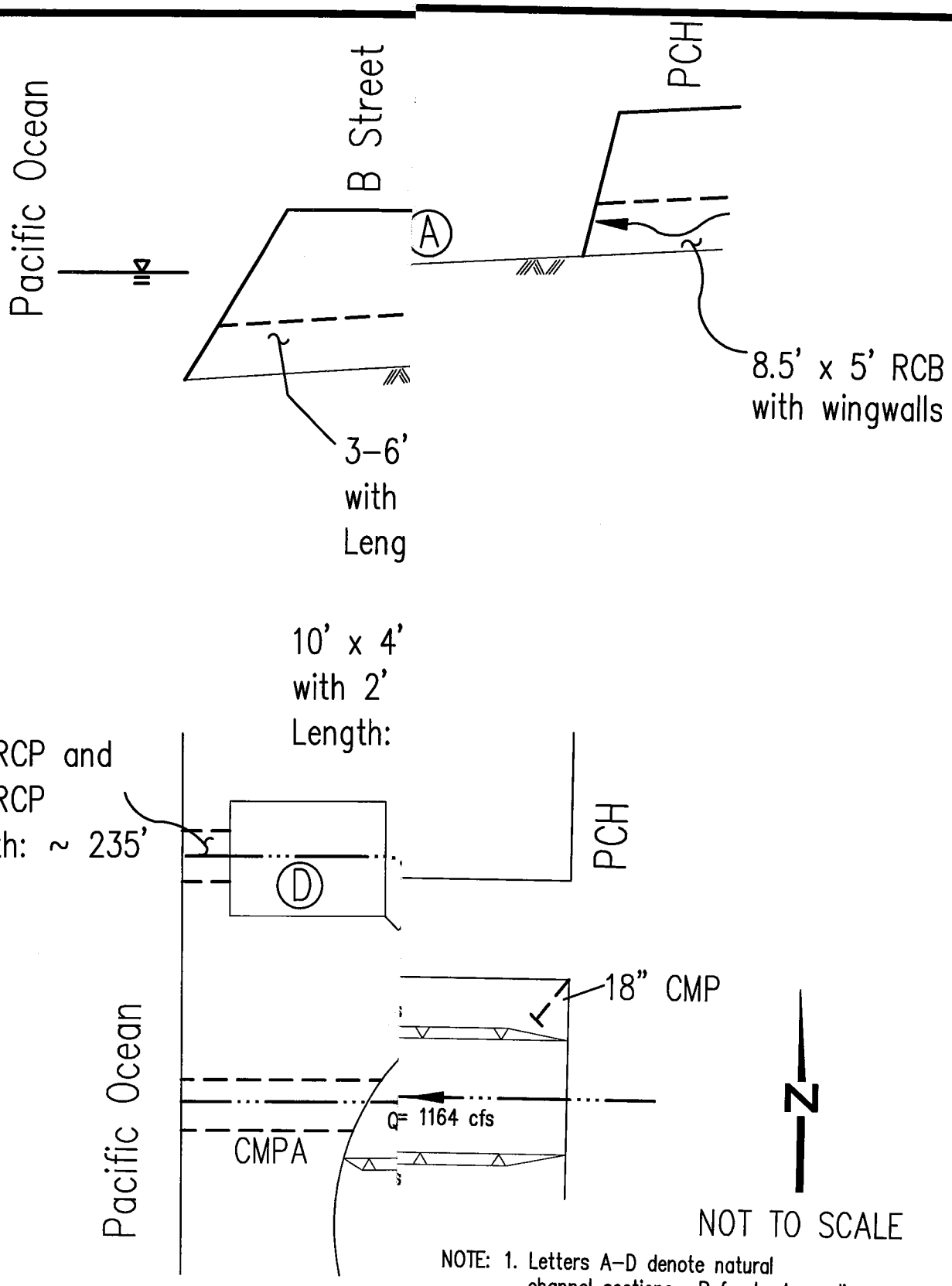
Hydraulic calculations for this analysis can be found in Appendix D.

Table 2: Existing Conditions Cottonwood Creek C

Location		Headwater Elevation (ft)	Depth (ft)
Between PCH and 3rd St.	A: ~ 35'	N/A	5.21
3rd St. Culvert Crossing	Dou	21.7	N/A
Between 3rd St. and 4th St.	B: 25' x	N/A	3.77
Between 3rd St. and Triple CMPA entrance	C: Irregu	N/A	7.40
Southern Ocean Outfall	Triple	6.11	N/A
B St. Culvert Crossing		8.24	N/A
Between B St. and Ocean Outfall	D: 10' x	N/A	4.63
Northern Ocean Outfall	60" F	8.23	N/A

Table 3: Proposed Alternatives Cottonwood Creek

Location	
3rd St. Culvert Crossing	Alt.A: 3-7' x 5' RCB w
	Alt. B: 2-6' x 4' RCB a
	Alt. C: 24' x 6' Conspa
B St. Culvert Crossing	Alt. A: 3-10' x 4' RCB
	Alt. B: 20' x 5' Conspa
Northern Ocean Outfall	Alt. A: 3-6' x 5' RCB v
	Alt. B: 16' x 5' Conspa
	Alt. C: 2- 60" RCP and



NOTE: 1. Letters A–D denote natural channel sections. Refer to Appendices for hydraulic information.

2. Hydraulic information about existing and proposed storm drain structures is found in the Appendix.

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PLOTTING VIEW: NONE
DESIGNER: NONE PROJ. MGR: JWG

XREFS: X11X17L

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DATE SUBMITTED: 04/09/03

SHEET NUMBER 1 OF 1 SHEETS

JOB NUMBER SD094800

APPENDIX A

EXISTING CONDITIONS: NATURAL CHANNEL HYDRAULIC CALCULATIONS

Natural Channel A: ~ 35'x 6'

Irregular Channel A
Worksheet for Irregular Channel

Project Description	
Worksheet	Irregular Channe
Flow Element	Irregular Channe
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Slope	015000	ft/ft
Discharg	,164.00	cfs

Options	
Current Roughness Meth	oved Lotter's Method
Open Channel Weighting	oved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.050	
Water Surface Elev	5.21	ft
Elevation Range	.00 to 7.00	
Flow Area	141.8	ft²
Wetted Perimeter	41.87	ft
Top Width	33.80	ft
Actual Depth	5.21	ft
Critical Elevation	4.31	ft
Critical Slope	0.031130	ft/ft
Velocity	8.21	ft/s
Velocity Head	1.05	ft
Specific Energy	6.25	ft
Froude Number	0.71	
Flow Type	Subcritical	

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+35	0.050

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	7.00
0+02	1.00
0+15	1.00
0+15	0.00
0+20	0.00
0+20	1.00
0+33	1.00
0+35	7.00

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Natural Channel B: 25' x 6.5'

Rectangular Channel B
Worksheet for Rectangular Channel

Project Description	
Worksheet	Rectangular Chan
Flow Element	Rectangular Chan
Method	Manning's Formul
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.030	
Slope	015000	ft/ft
Bottom Width	25.00	ft
Discharge	,164.00	cfs

Results		
Depth	3.77	ft
Flow Area	94.4	ft²
Wetted Perim	32.55	ft
Top Width	25.00	ft
Critical Depth	4.07	ft
Critical Slope	0.011961	ft/ft
Velocity	12.33	ft/s
Velocity Head	2.36	ft
Specific Energ	6.14	ft
Froude Numb	1.12	
Flow Type	Supercritical	

Natural Channel C: Irregular

Irregular Rectangular Channel C
Worksheet for Irregular Channel

Project Description	
Worksheet	Irregular Channe
Flow Element	Irregular Channe
Method	Manning's Formi
Solve For	Channel Depth

Input Data		
Slope	015000	ft/ft
Discharg	,164.00	cfs

Options	
Current Roughness Metho	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.047	
Water Surface Elev	7.40	ft
Elevation Range	.00 to 8.00	
Flow Area	147.3	ft²
Wetted Perimeter	50.98	ft
Top Width	38.00	ft
Actual Depth	7.40	ft
Critical Elevation	6.60	ft
Critical Slope	0.030998	ft/ft
Velocity	7.90	ft/s
Velocity Head	0.97	ft
Specific Energy	8.37	ft
Froude Number	0.71	
Flow Type	Subcritical	

Calculation Messages:
Water elevation exceeds lowest end station by 2.4022296 ft.

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+20	0.050
0+20	0+27	0.040
0+27	0+38	0.050

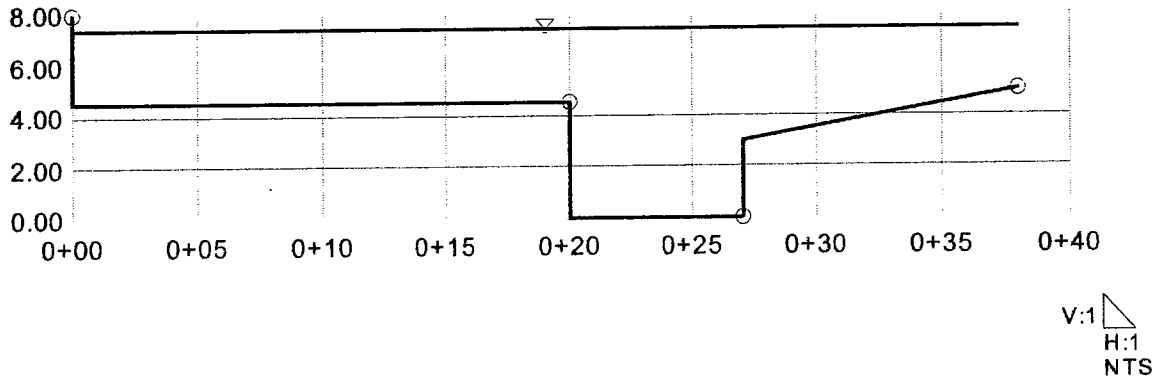
Natural Channel Points

Station (ft)	Elevation (ft)
0+00	8.00
0+00	4.50
0+20	4.50
0+20	0.00
0+27	0.00
0+27	3.00
0+38	5.00

Cross Section
Cross Section for Irregular Channel

Project Description	
Worksheet	Irregular Channe
Flow Element	Irregular Channe
Method	Manning's Form
Solve For	Channel Depth

Section Data		
Mannings Coefficie	0.047	
Slope	0.015000	ft/ft
Water Surface Elev	7.40	ft
Elevation Range	.00 to 8.00	
Discharge	1,164.00	cfs



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Natural Channel D: 10' x 5.5'

Rectangular Channel D
Worksheet for Rectangular Channel

Project Description	
Worksheet	Rectangular Chan
Flow Element	Rectangular Chan
Method	Manning's Formul
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.030	
Slope	015000	ft/ft
Bottom Width	10.00	ft
Discharge	504.00	cfs

Results		
Depth	4.63	ft
Flow Area	46.3	ft²
Wetted Perim	19.26	ft
Top Width	10.00	ft
Critical Depth	4.29	ft
Critical Slope	0.018436	ft/ft
Velocity	10.89	ft/s
Velocity Head	1.84	ft
Specific Ener	6.47	ft
Froude Numb	0.89	
Flow Type	Subcritical	

APPENDIX B

EXISTING CONDITIONS: STORM DRAIN FACILITIES CALCULATIONS

Third Street Culvert Crossing

Double 6' x 4' RCB

Culvert Calculator Report
6x4 Double Box Culvert (Existing)

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	24.15	ft	Headwater Depth/Height	5.42	
Computed Headwater Elev	37.85	ft	Discharge	1,164.00	cfs
Inlet Control HW Elev.	37.85	ft	Tailwater Elevation	17.81	ft
Outlet Control HW Elev.	33.14	ft	Control Type	Inlet Control	

Grades					
Upstream Invert	16.15	ft	Downstream Invert	14.04	ft
Length	88.00	ft	Constructed Slope	0.023977	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	4.00	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	4.00	ft
Velocity Downstream	24.25	ft/s	Critical Slope	0.046994	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.015	
Section Material	Concrete		Span	6.00	ft
Section Size	6 x 4 ft		Rise	4.00	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	33.14	ft	Upstream Velocity Head	9.14	ft
Ke	0.20		Entrance Loss	1.83	ft

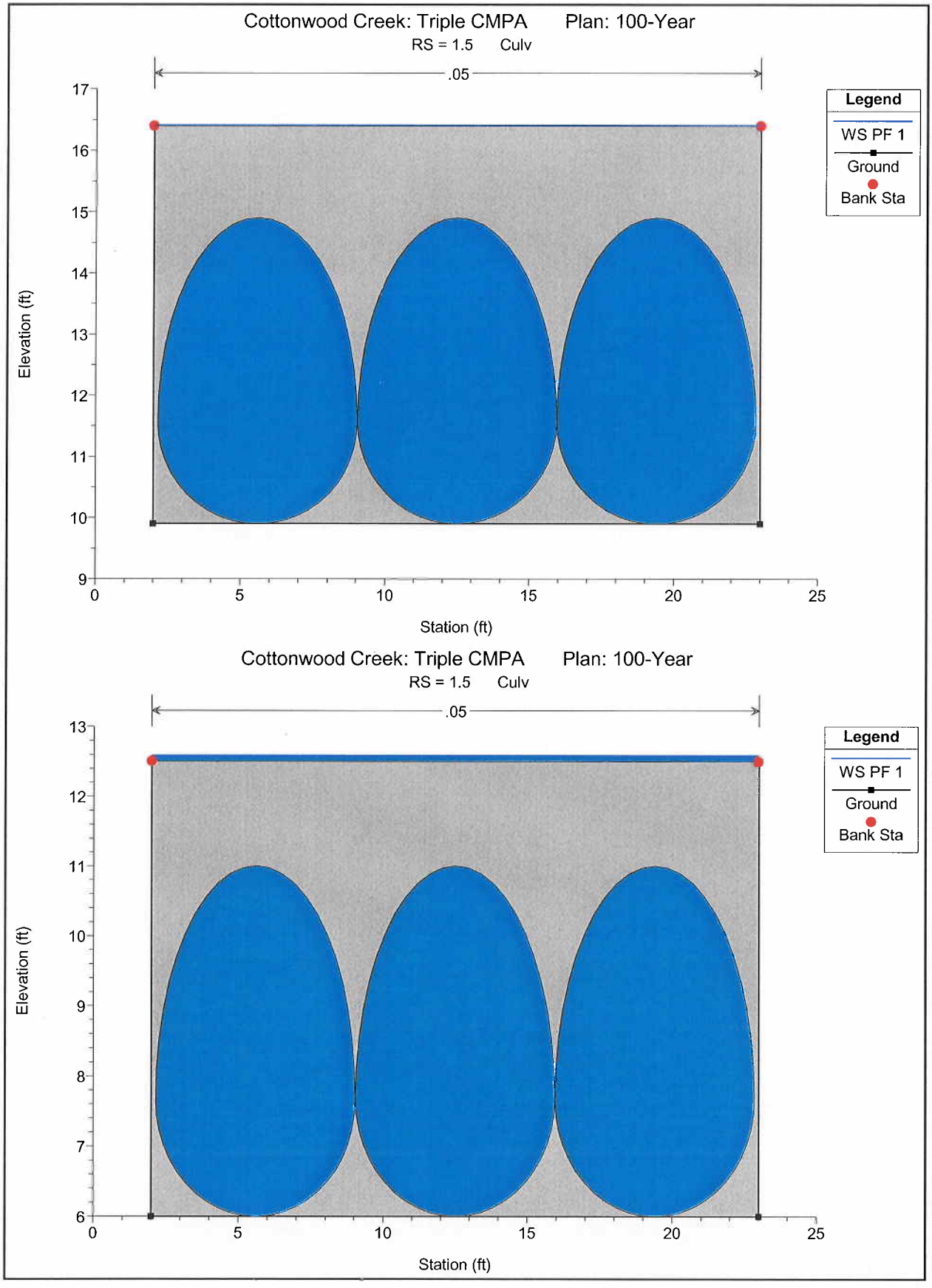
Inlet Control Properties					
Inlet Control HW Elev.	37.85	ft	Flow Control	N/A	
Inlet Type	90° headwall w 45° bevels		Area Full	48.0	ft²
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

Southern Ocean Outfall

Triple 6'-8" x 5' CMPA

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Ocean Outfall Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ocean Outfall	2	PF 1	750.00	9.90	16.01	13.30	16.54	0.006398	5.85	128.21	21.00	0.42
Ocean Outfall	1.5		Culvert									
Ocean Outfall	1	PF 1	750.00	6.00	10.54	9.40	11.50	0.015003	7.86	95.44	21.00	0.65


Cottonwood Creek: Triple CMPA Plan: 100-Year
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
17
16
15
14
13
12
11
10
9
0
5
10
15
20
25
Cottonwood Creek: Triple CMPA Plan: 100-Year
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
13
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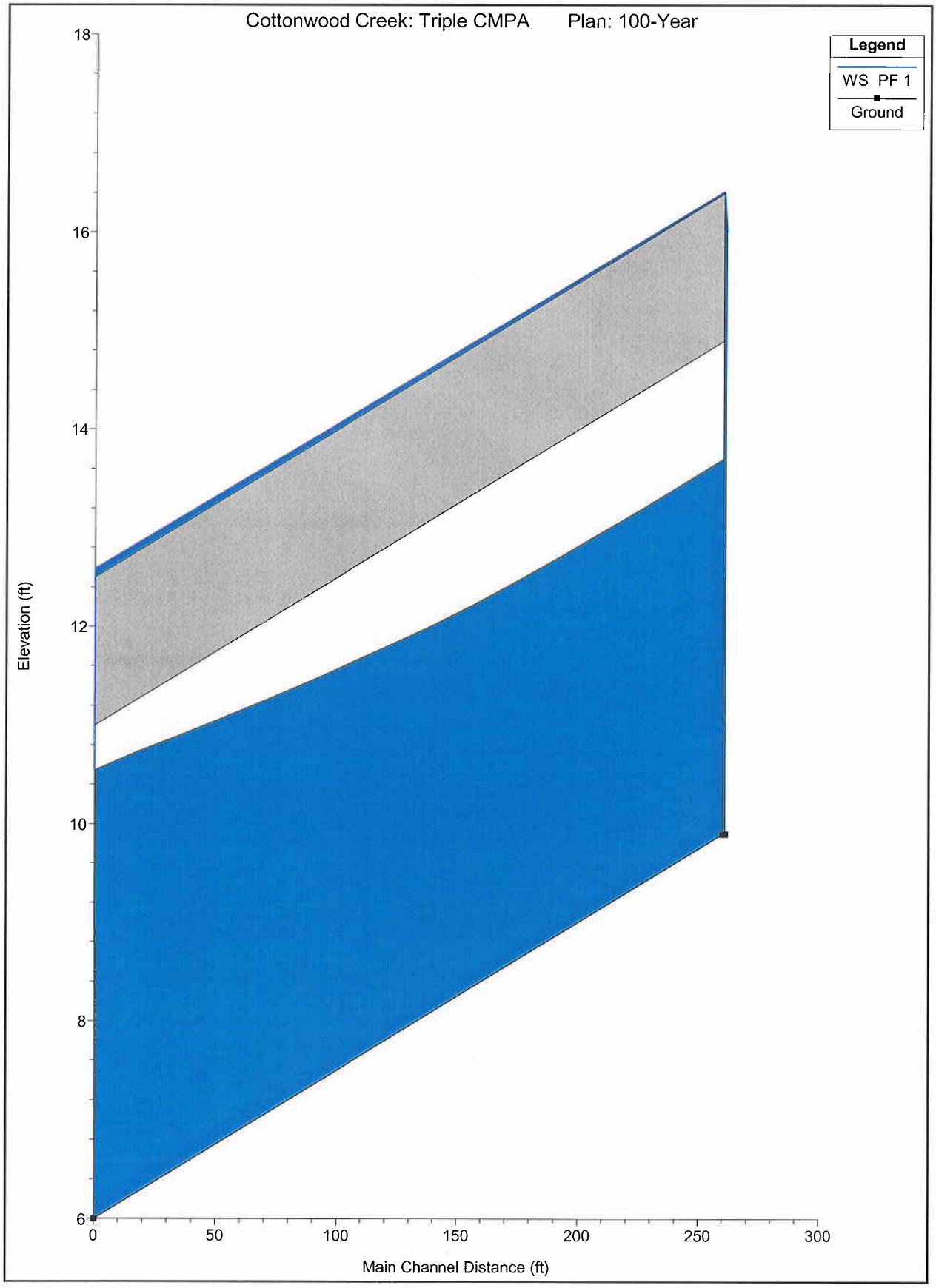

Cottonwood Creek: Triple CMPA
Plan: 100-Year
Legend
WS PF 1
Ground
Elevation (ft)
18
16
14
12
10
8
6
0
50
100
150
200
250
300
Main Channel Distance (ft)

B Street Culvert Crossing

10'x4' RCB

Culvert Calculator Report
10x4 Box Culvert (Existing)

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	15.00	ft	Headwater Depth/Height	2.06	
Computed Headwater Elev	17.24	ft	Discharge	504.00	cfs
Inlet Control HW Elev.	17.24	ft	Tailwater Elevation	13.63	ft
Outlet Control HW Elev.	17.19	ft	Control Type	Inlet Control	

Grades					
Upstream Invert	9.00	ft	Downstream Invert	8.10	ft
Length	60.00	ft	Constructed Slope	0.015000	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	3.34	ft
Slope Type	N/A		Normal Depth	2.81	ft
Flow Regime	N/A		Critical Depth	4.00	ft
Velocity Downstream	15.10	ft/s	Critical Slope	0.010055	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.015	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 4 ft		Rise	4.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	17.19	ft	Upstream Velocity Head	2.47	ft
Ke	0.20		Entrance Loss	0.49	ft

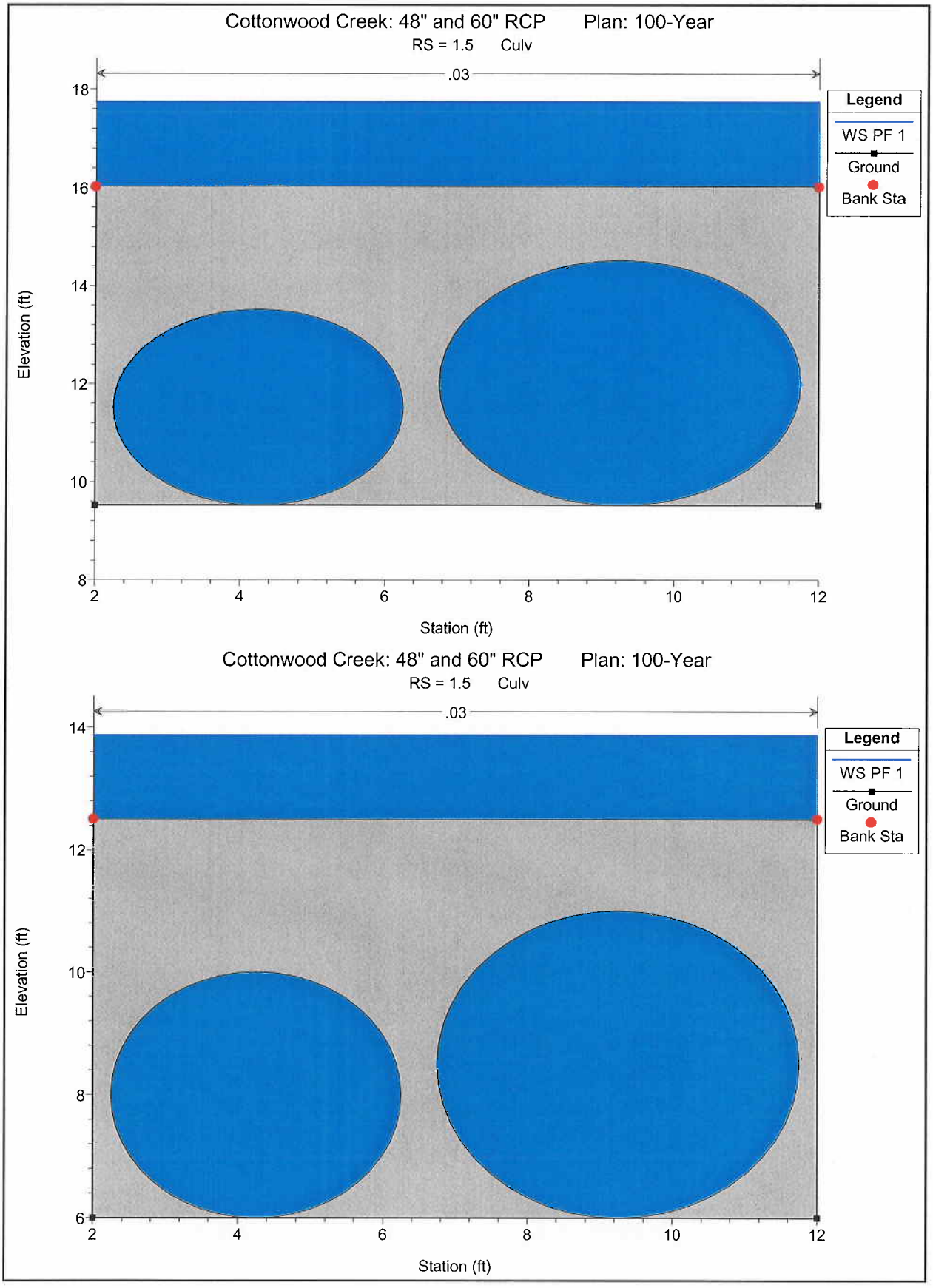
Inlet Control Properties					
Inlet Control HW Elev.	17.24	ft	Flow Control	N/A	
Inlet Type	90° headwall w 45° bevels		Area Full	40.0	ft²
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

Northern Ocean Outfall

60" RCP and 48" RCP

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Beach Outfall Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Beach Outfall	2	PF 1	504.00	9.52	17.75	13.80	18.33	0.003367	6.12	82.29	10.00	0.38
Beach Outfall	1.5		Culvert									
Beach Outfall	1	PF 1	504.00	6.00	10.63	10.27	12.47	0.015001	10.89	46.30	10.00	0.89


Cottonwood Creek: 48" and 60" RCP Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
18
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Cottonwood Creek: 48" and 60" RCP Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
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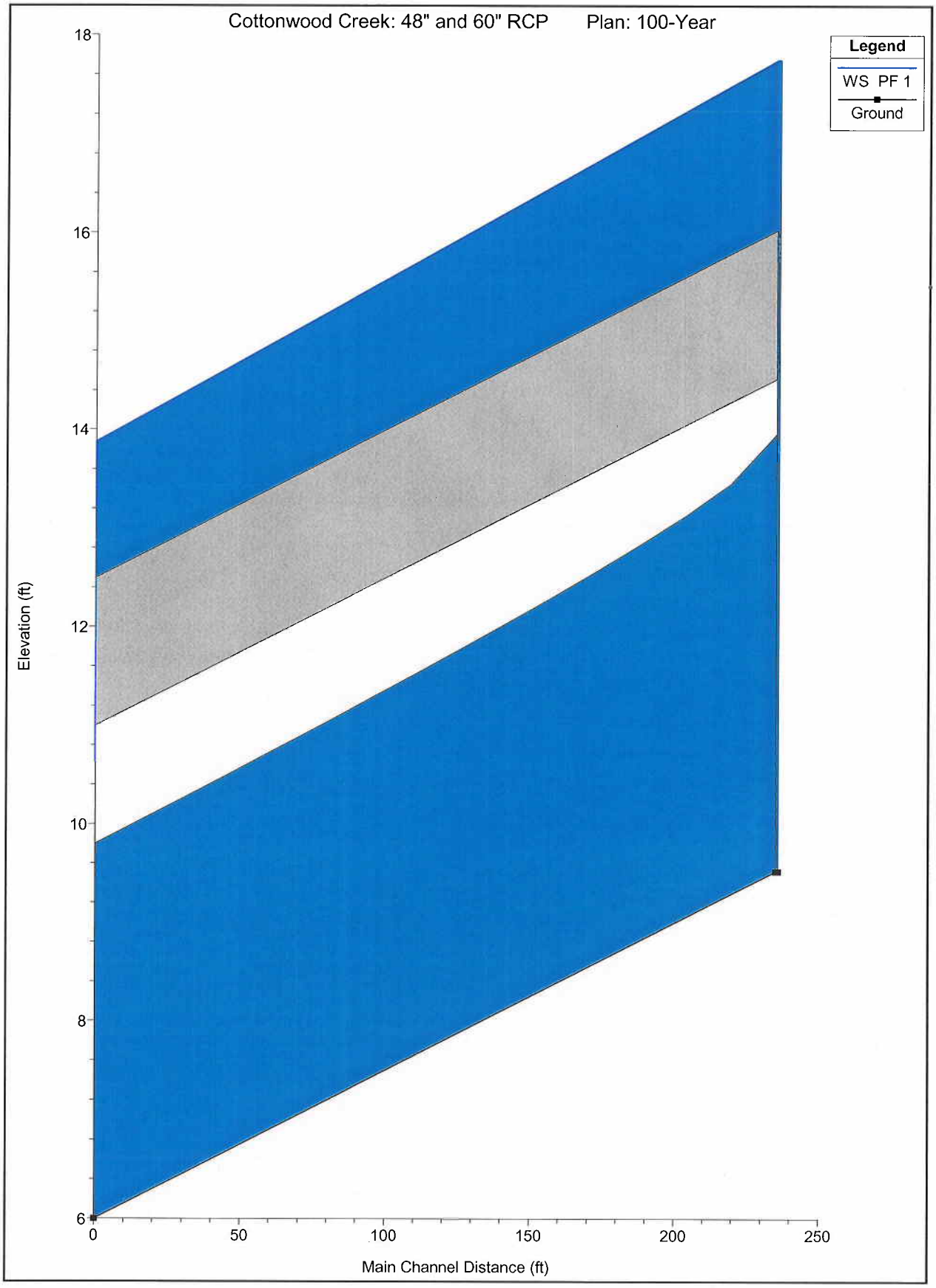

Cottonwood Creek: 48" and 60" RCP
Plan: 100-Year
Legend
WS PF 1
Ground
Elevation (ft)
18
16
14
12
10
8
6
0
50
100
150
200
250
Main Channel Distance (ft)

APPENDIX C

PROPOSED ALTERNATIVES: STORM DRAIN FACILITIES CALCULATIONS

Third Street Culvert Crossing

Alternative A: 3-7' x 5' RCB w/ 3' headwall
Alternative B: 2-6' x 4' RCB and 1-10' x 4' RCB
Alternative C: 24' x 6' Conspan Bridge

Alternative A: 3-7' x 5' RCB w/ 3' headwall

Culvert Calculator Report
Alternative A

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	24.15 ft	Headwater Depth/Height	1.58
Computed Headwater Elev	24.05 ft	Discharge	1,164.00 cfs
Inlet Control HW Elev.	24.05 ft	Tailwater Elevation	17.81 ft
Outlet Control HW Elev.	23.46 ft	Control Type	Inlet Control

Grades			
Upstream Invert	16.15 ft	Downstream Invert	14.04 ft
Length	88.00 ft	Constructed Slope	0.023977 ft/ft

Hydraulic Profile			
Profile	S2	Depth, Downstream	3.18 ft
Slope Type	Steep	Normal Depth	2.72 ft
Flow Regime	Supercritical	Critical Depth	4.57 ft
Velocity Downstream	17.42 ft/s	Critical Slope	0.006019 ft/ft

Section			
Section Shape	Box	Mannings Coefficient	0.015
Section Material	Concrete	Span	7.00 ft
Section Size	7 x 5 ft	Rise	5.00 ft
Number Sections	3		

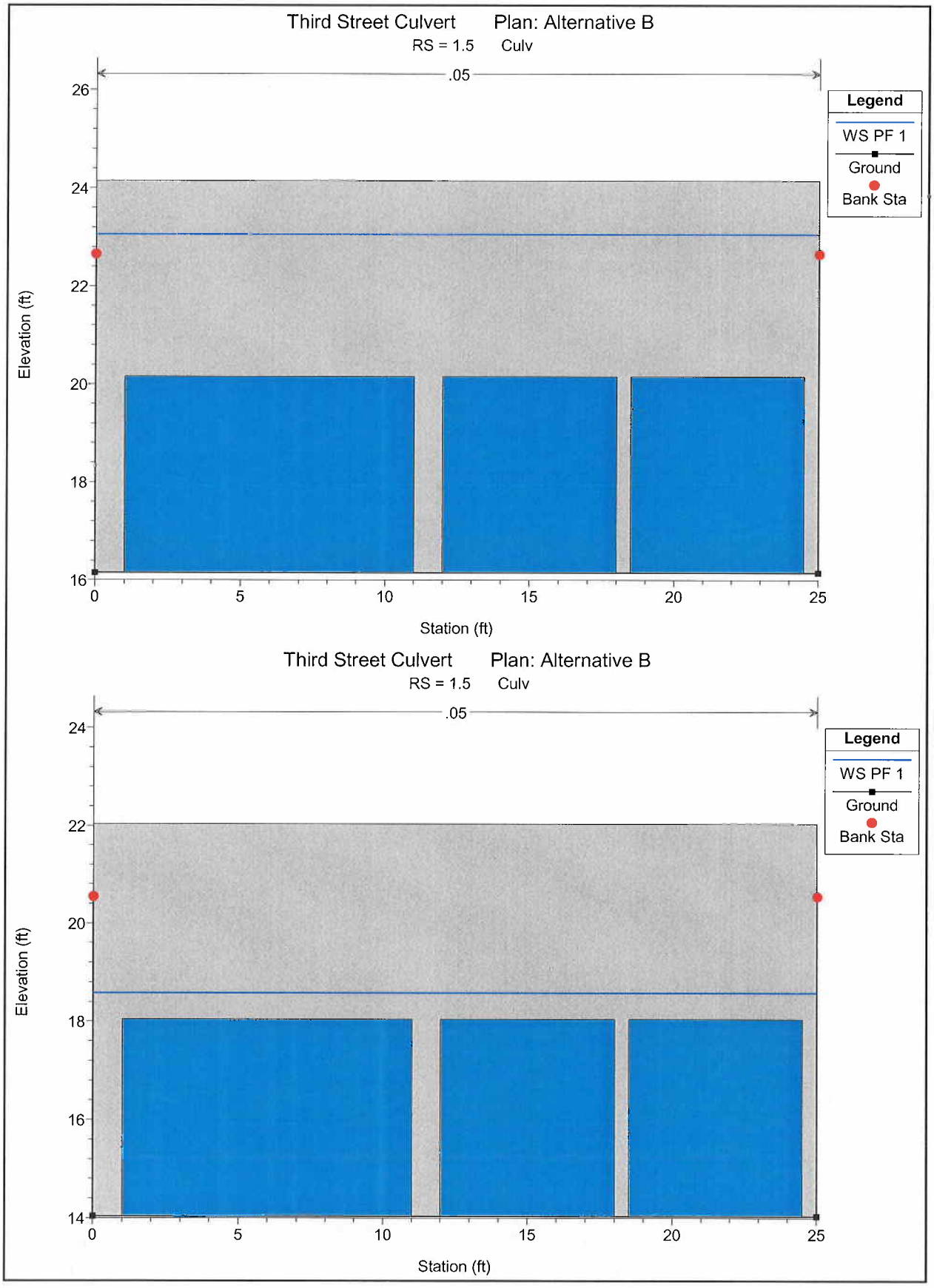
Outlet Control Properties			
Outlet Control HW Elev.	23.46 ft	Upstream Velocity Head	2.29 ft
Ke	0.20	Entrance Loss	0.46 ft

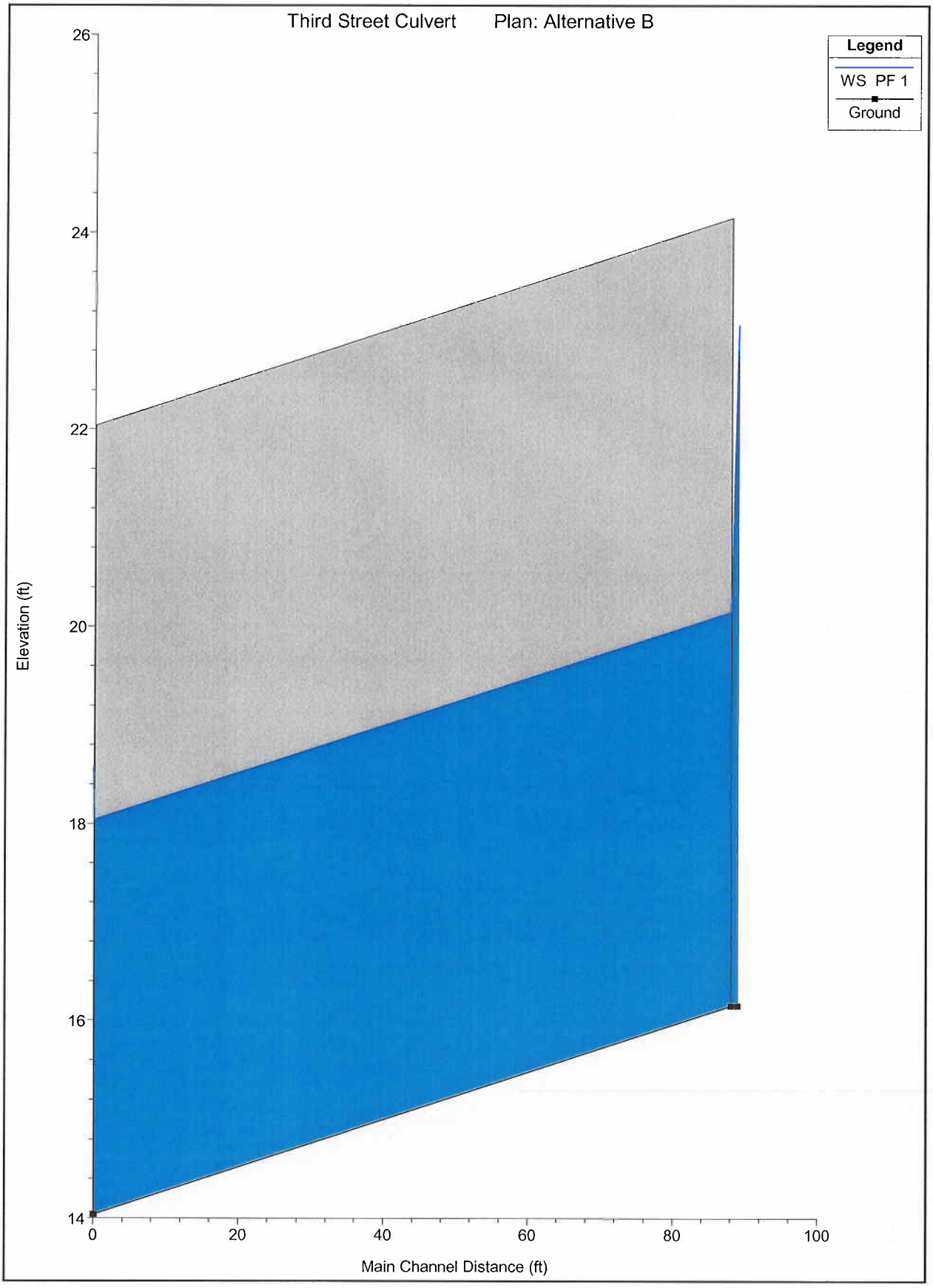
Inlet Control Properties			
Inlet Control HW Elev.	24.05 ft	Flow Control	Submerged
Inlet Type	90° headwall w 45° bevels	Area Full	105.0 ft²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Alternative B: 2-6' x 4' RCB and 1-10' x 4' RCB

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Third Street Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Third Street	2	PF 1	1164.00	16.15	23.06	20.22	23.76	0.007031	6.74	172.68	25.00	0.45
Third Street	1.5		Culvert									
Third Street	1	PF 1	1164.00	14.04	18.58	18.11	20.21	0.024007	10.26	113.40	25.00	0.85

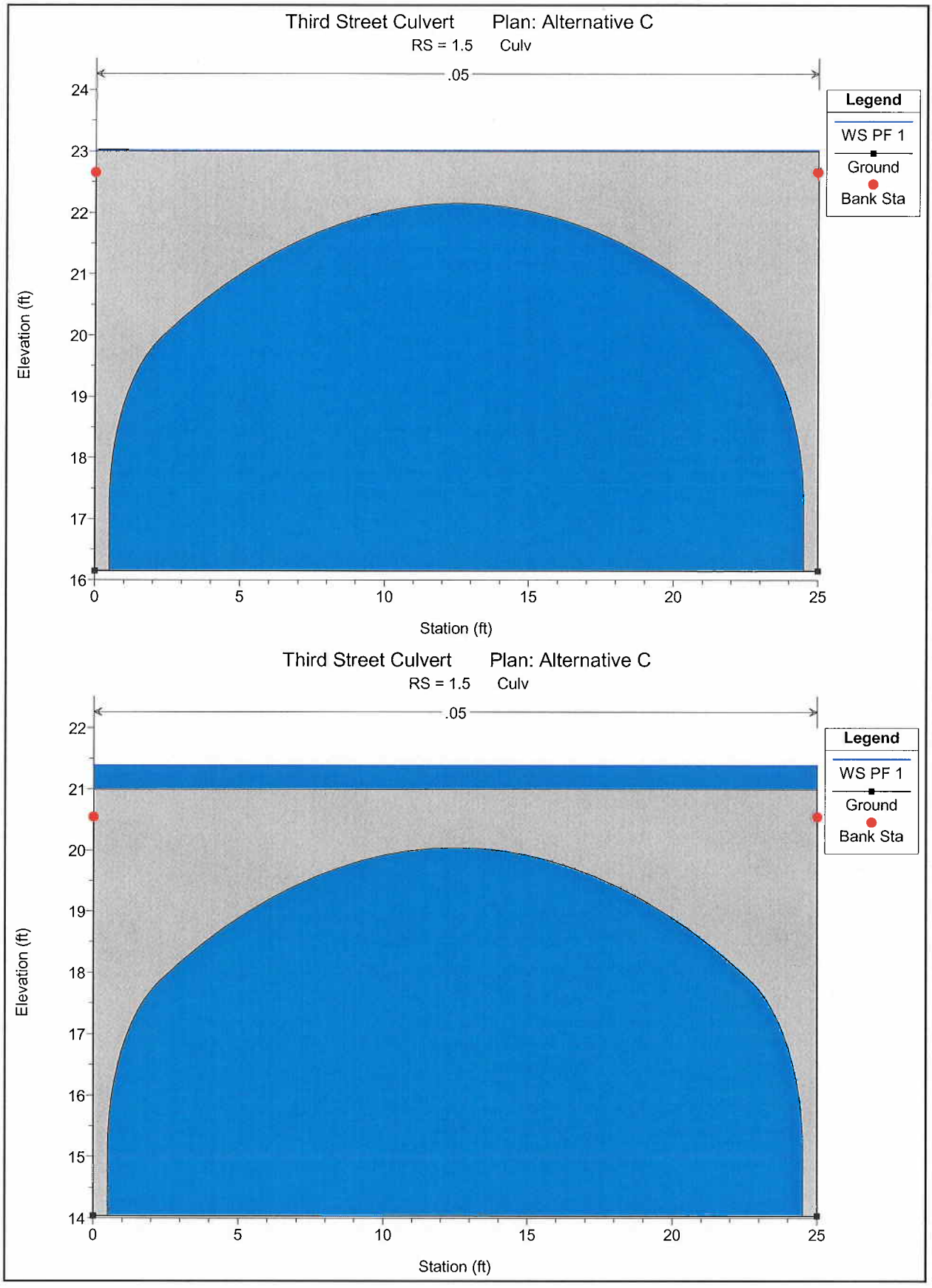

Third Street Culvert Plan: Alternative B
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
26
24
22
20
18
16
0
5
10
15
20
25
Third Street Culvert Plan: Alternative B
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
24
22
20
18
16
14
0
5
10
15
20
25

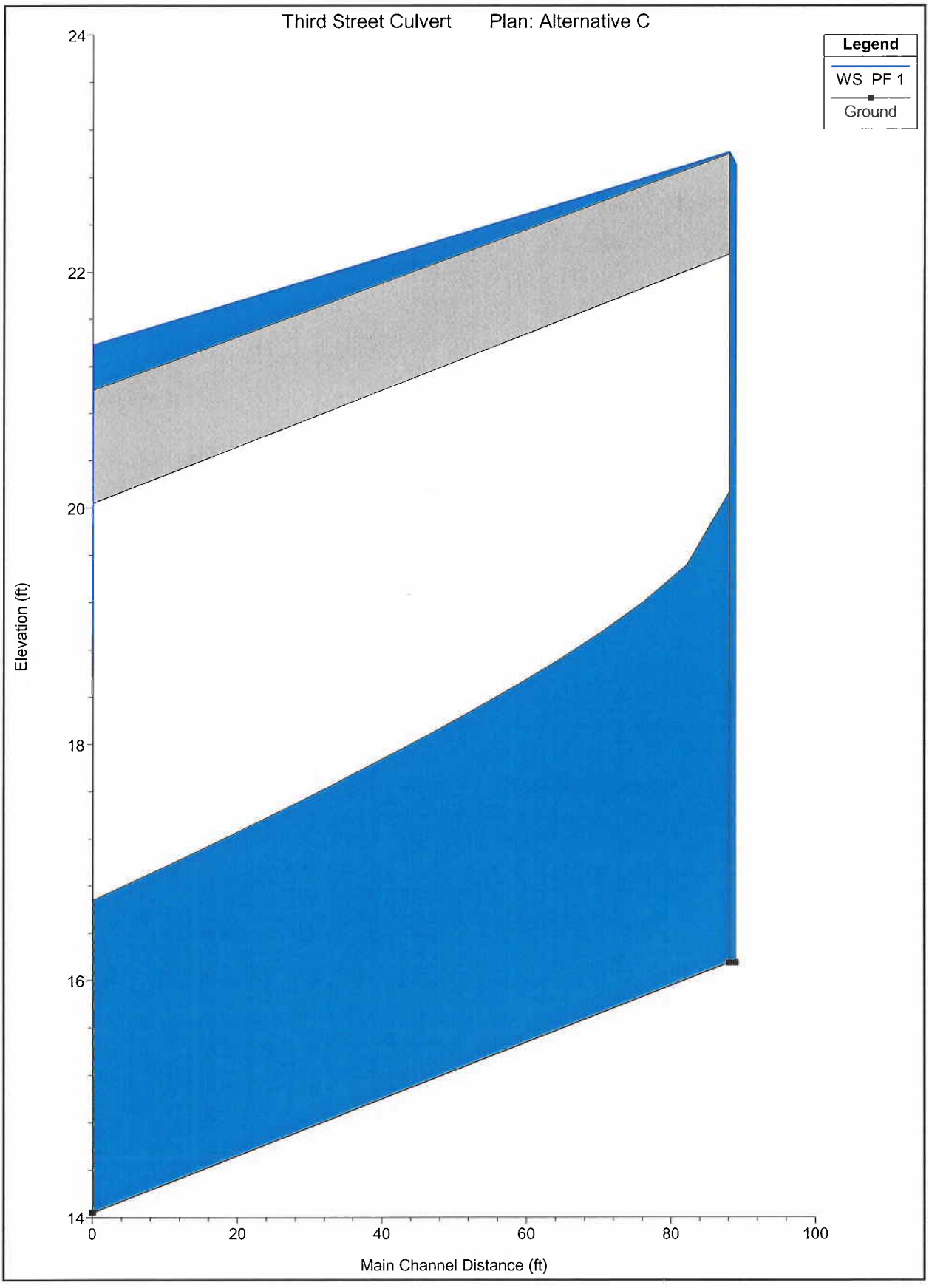

Third Street Culvert
Plan: Alternative B
Legend
WS PF 1
Ground
Elevation (ft)
26
24
22
20
18
16
14
0
20
40
60
80
100
Main Channel Distance (ft)

Alternative C: 24' x 6' Conspan Bridge

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Third Street Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Third Street	2	PF 1	1164.00	16.15	22.90	20.22	23.64	0.007496	6.89	168.86	25.00	0.47
Third Street	1.5		Culvert									
Third Street	1	PF 1	1164.00	14.04	18.58	18.11	20.21	0.024007	10.26	113.40	25.00	0.85


Third Street Culvert Plan: Alternative C
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
24
23
22
21
20
19
18
17
16
0
5
10
15
20
25
Third Street Culvert Plan: Alternative C
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
22
21
20
19
18
17
16
15
14
0
5
10
15
20
25


Third Street Culvert Plan: Alternative C
Legend
WS PF 1
Ground
Elevation (ft)
24
22
20
18
16
14
0
20
40
60
80
100
Main Channel Distance (ft)

B Street Culvert Crossing

Alternative A: 3-10' x 4' RCB w/ 2' headwall
Alternative B: 20' x 5' Conspan Bridge

Alternative A: 3-10' x 4' RCB w/ 2' headwall

Culvert Calculator Report
10x4 Box Culvert Alternative A

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	15.00 ft	Headwater Depth/Height	1.39
Computed Headwater Elev	14.57 ft	Discharge	674.00 cfs
Inlet Control HW Elev.	13.86 ft	Tailwater Elevation	13.86 ft
Outlet Control HW Elev.	14.57 ft	Control Type	Outlet Control

Grades			
Upstream Invert	9.00 ft	Downstream Invert	8.10 ft
Length	60.00 ft	Constructed Slope	0.015000 ft/ft

Hydraulic Profile			
Profile	PressureProfile	Depth, Downstream	5.76 ft
Slope Type	N/A	Normal Depth	1.62 ft
Flow Regime	N/A	Critical Depth	2.50 ft
Velocity Downstream	5.62 ft/s	Critical Slope	0.004149 ft/ft

Section			
Section Shape	Box	Mannings Coefficient	0.015
Section Material	Concrete	Span	10.00 ft
Section Size	10 x 4 ft	Rise	4.00 ft
Number Sections	3		

Outlet Control Properties			
Outlet Control HW Elev.	14.57 ft	Upstream Velocity Head	0.49 ft
Ke	0.20	Entrance Loss	0.10 ft

Inlet Control Properties			
Inlet Control HW Elev.	13.86 ft	Flow Control	Unsubmerged
Inlet Type	90° headwall w 45° bevels	Area Full	120.0 ft²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

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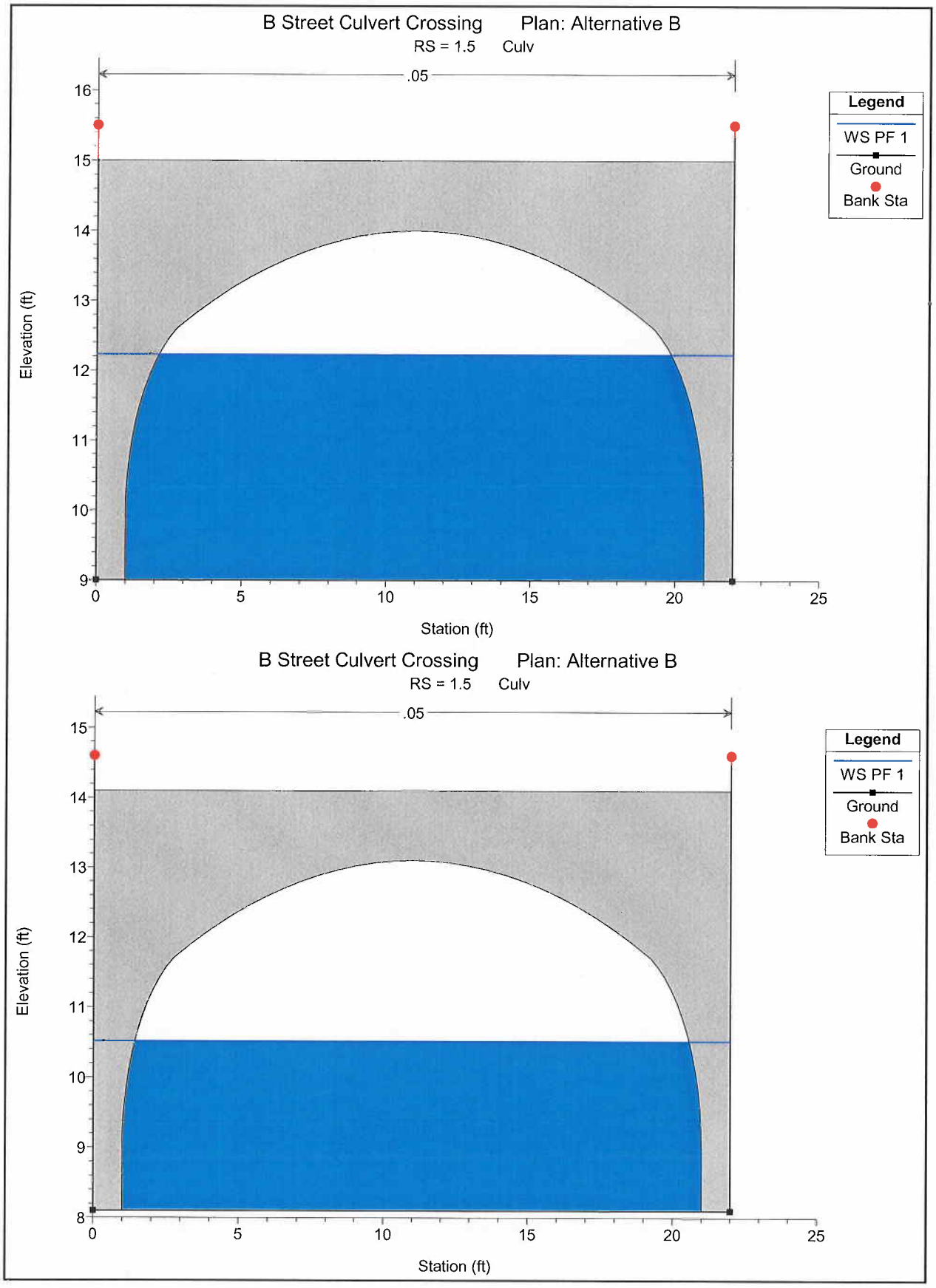
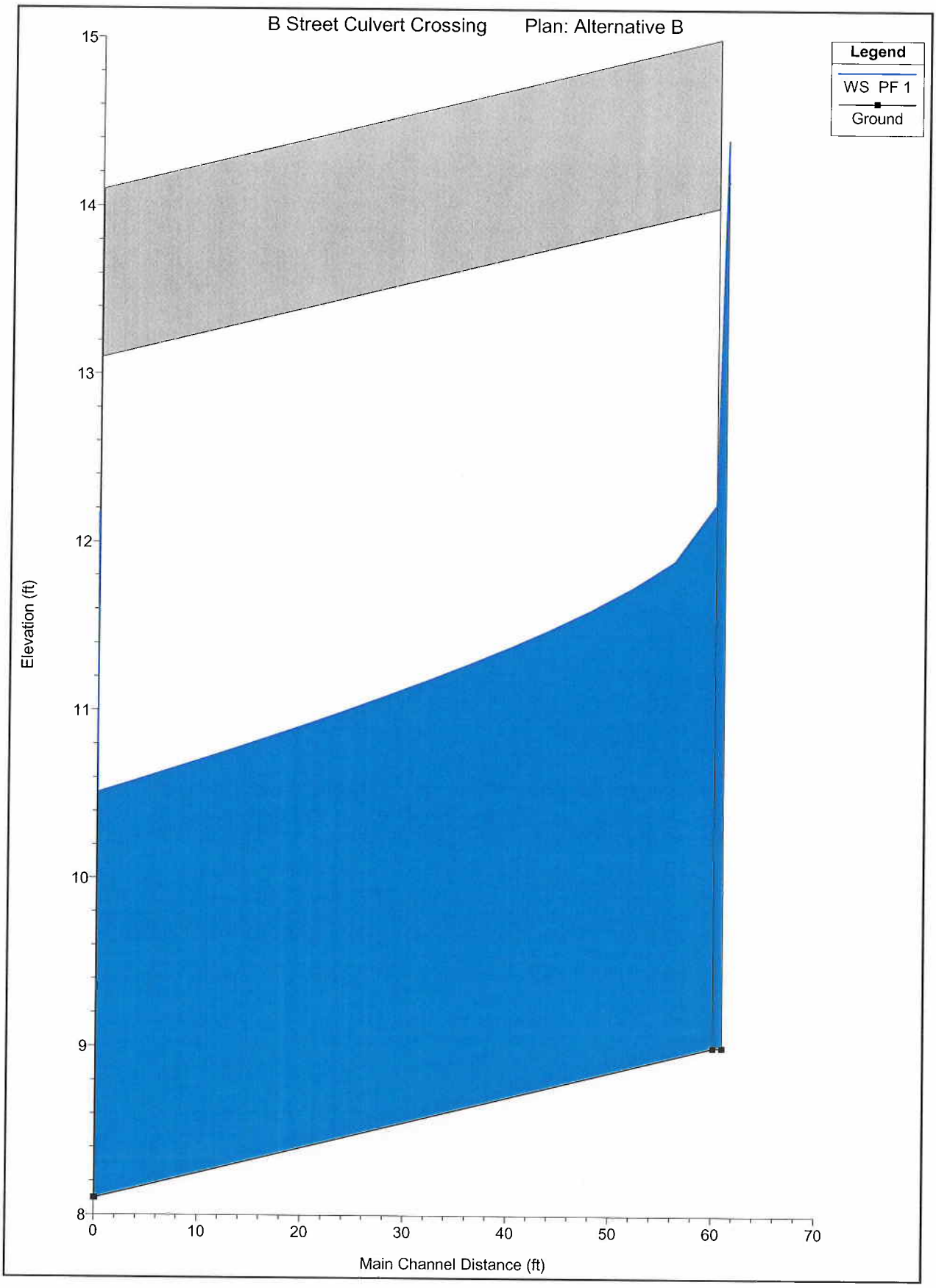
Alternative B: 20' x 5' Conspan Bridge

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: B Street Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
B Street	2	PF 1	674.00	9.00	14.40	12.07	14.90	0.006549	5.67	118.82	22.00	0.43
B Street	1.5		Culvert									
B Street	1	PF 1	674.00	8.10	12.17	11.17	13.05	0.015013	7.53	89.56	22.00	0.66


B Street Culvert Crossing Plan: Alternative B
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
16
15
14
13
12
11
10
9
0
5
10
15
20
25
B Street Culvert Crossing Plan: Alternative B
RS = 1.5 Culv
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
15
14
13
12
11
10
9
8
0
5
10
15
20
25


B Street Culvert Crossing
Plan: Alternative B
Legend
WS PF 1
Ground
Elevation (ft)
15
14
13
12
11
10
9
8
0
10
20
30
40
50
60
70
Main Channel Distance (ft)

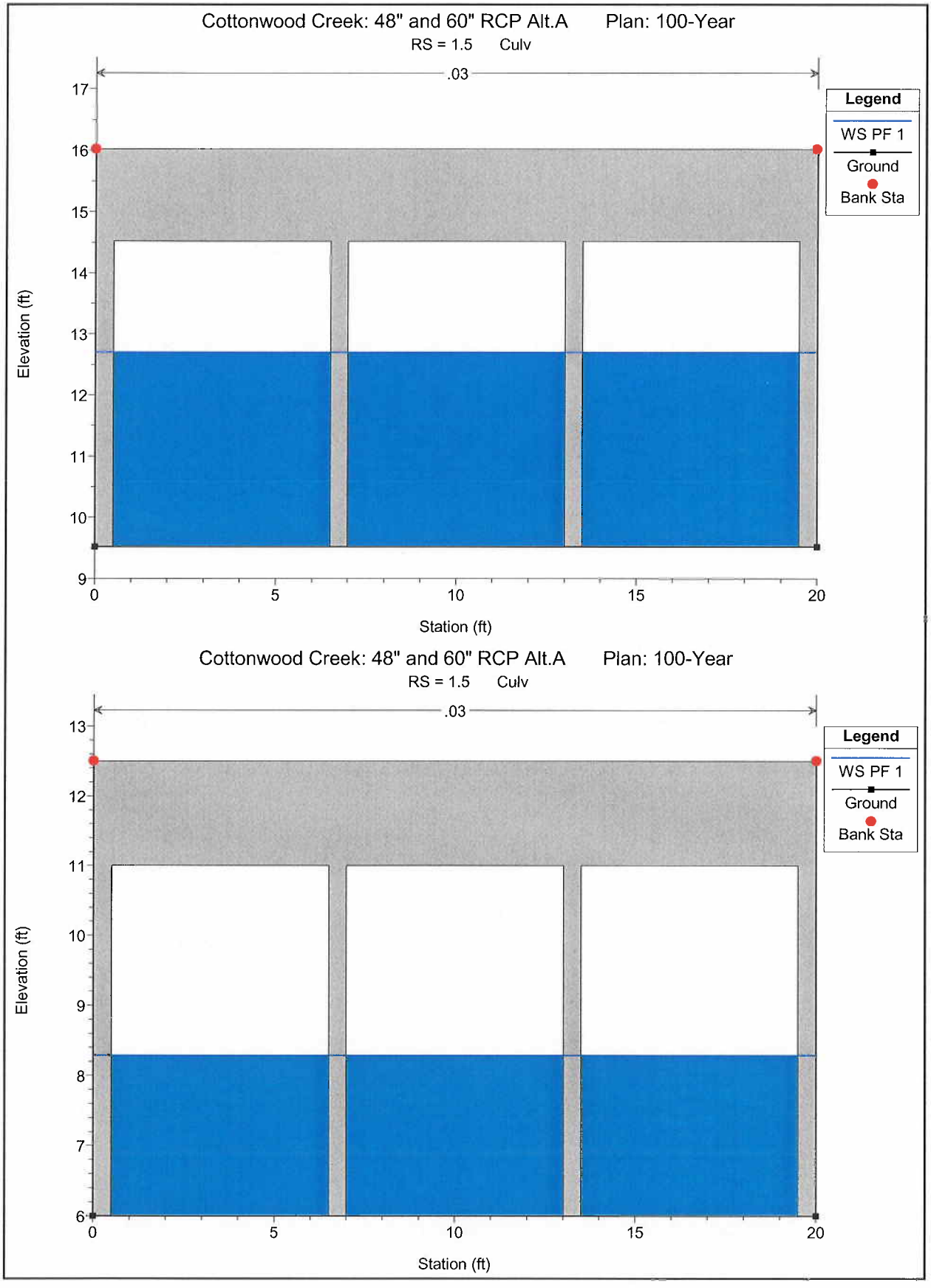
Northern Ocean Outfall

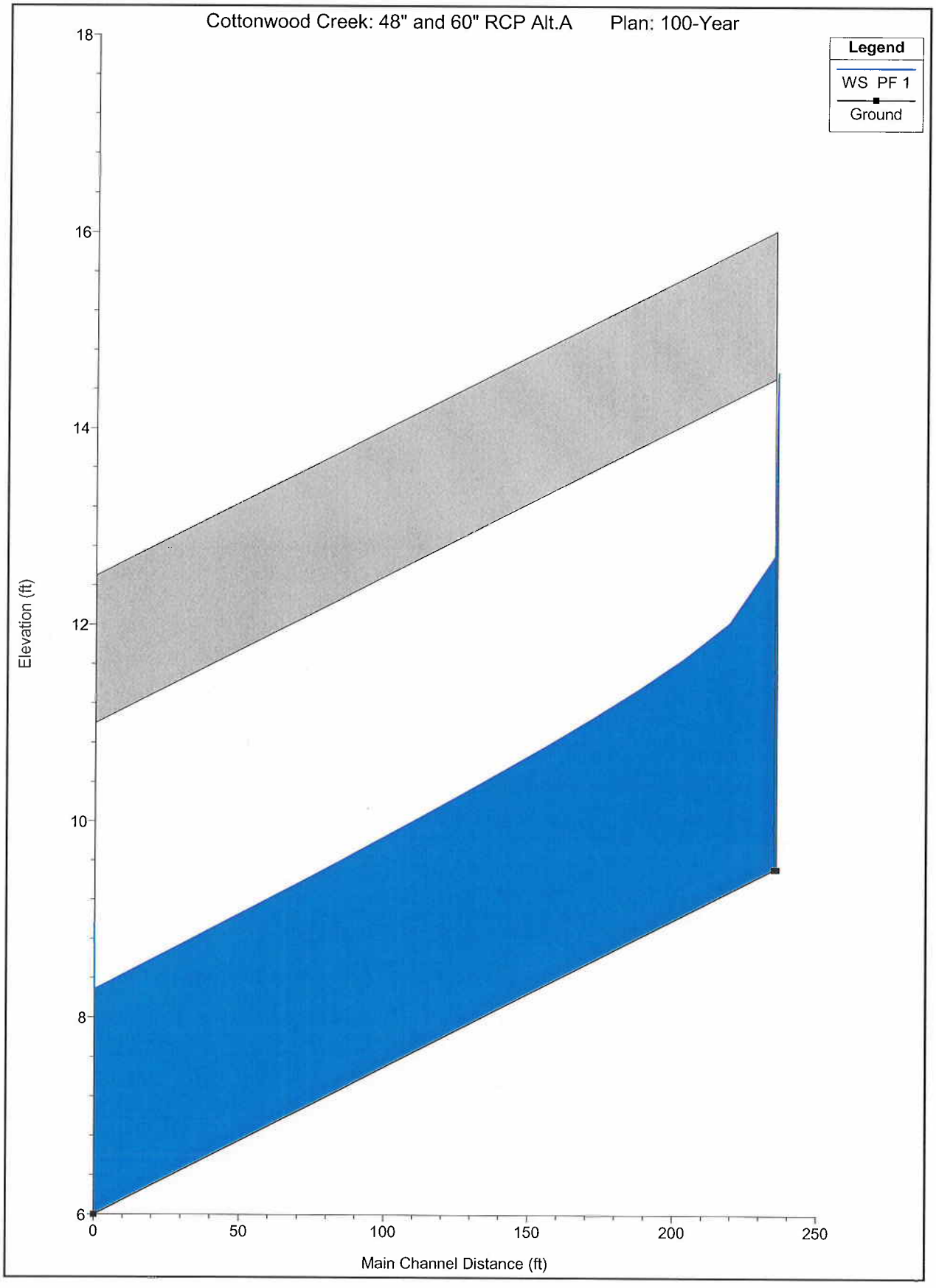
Alternative A: 3-6' x 5' RCB w/ 1.5' headwall
Alternative B: 16' x 5' Conspan Bridge
Alternative C: 2- 60" RCP and 48" RCP

Alternative A: 3-6' x 5' RCB w/ 1.5' headwall

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Ocean Outfall Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ocean Outfall	2	PF 1	580.00	9.52	14.58	12.48	15.09	0.002661	5.73	101.19	20.00	0.45
Ocean Outfall	1.5		Culvert									
Ocean Outfall	1	PF 1	580.00	6.00	8.96	8.96	10.45	0.013061	9.81	59.12	20.00	1.01

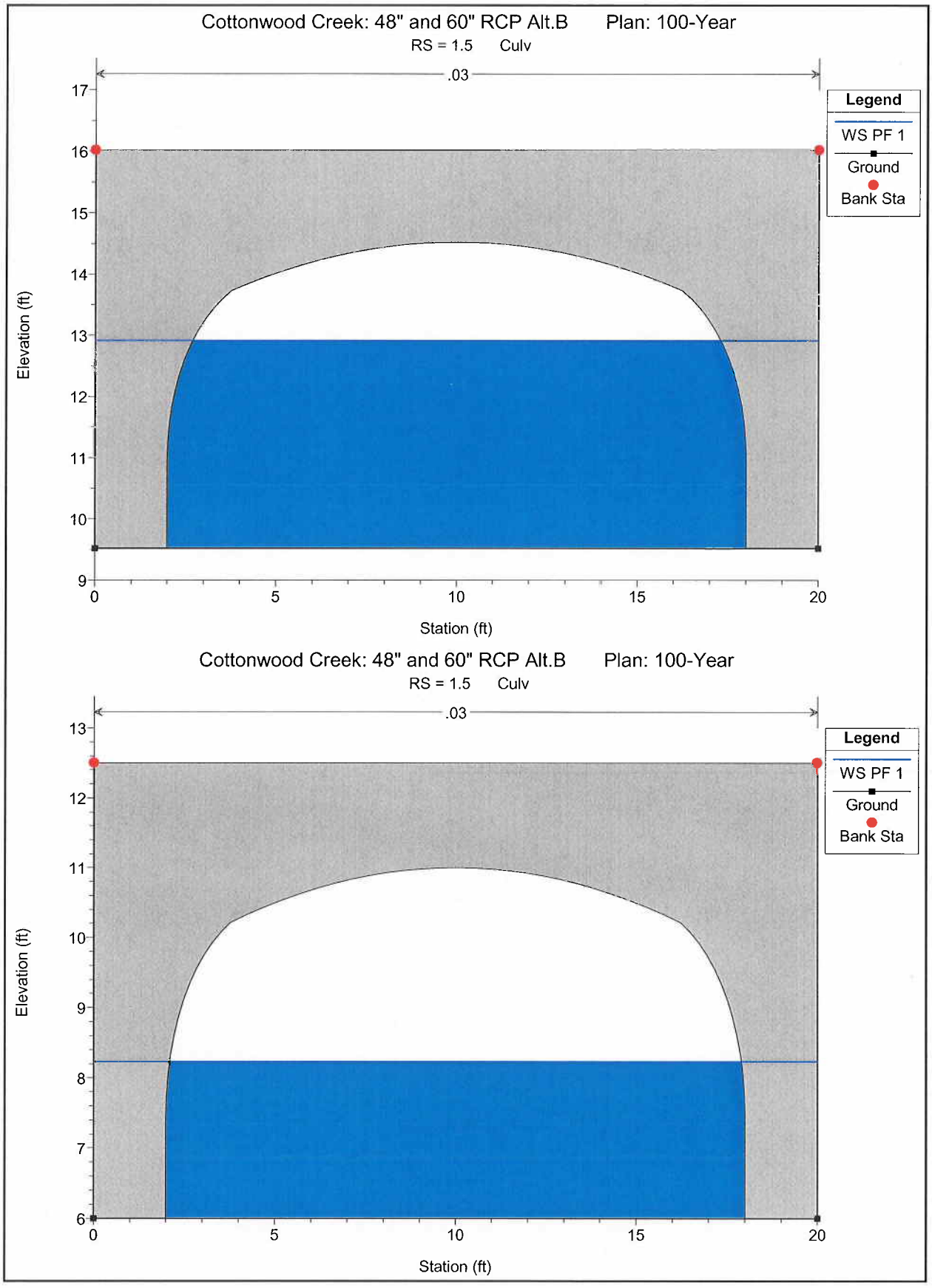

Cottonwood Creek: 48" and 60" RCP Alt.A Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
17
16
15
14
13
12
11
10
9
0
5
10
15
20
Cottonwood Creek: 48" and 60" RCP Alt.A Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
13
12
11
10
9
8
7
6
0
5
10
15
20

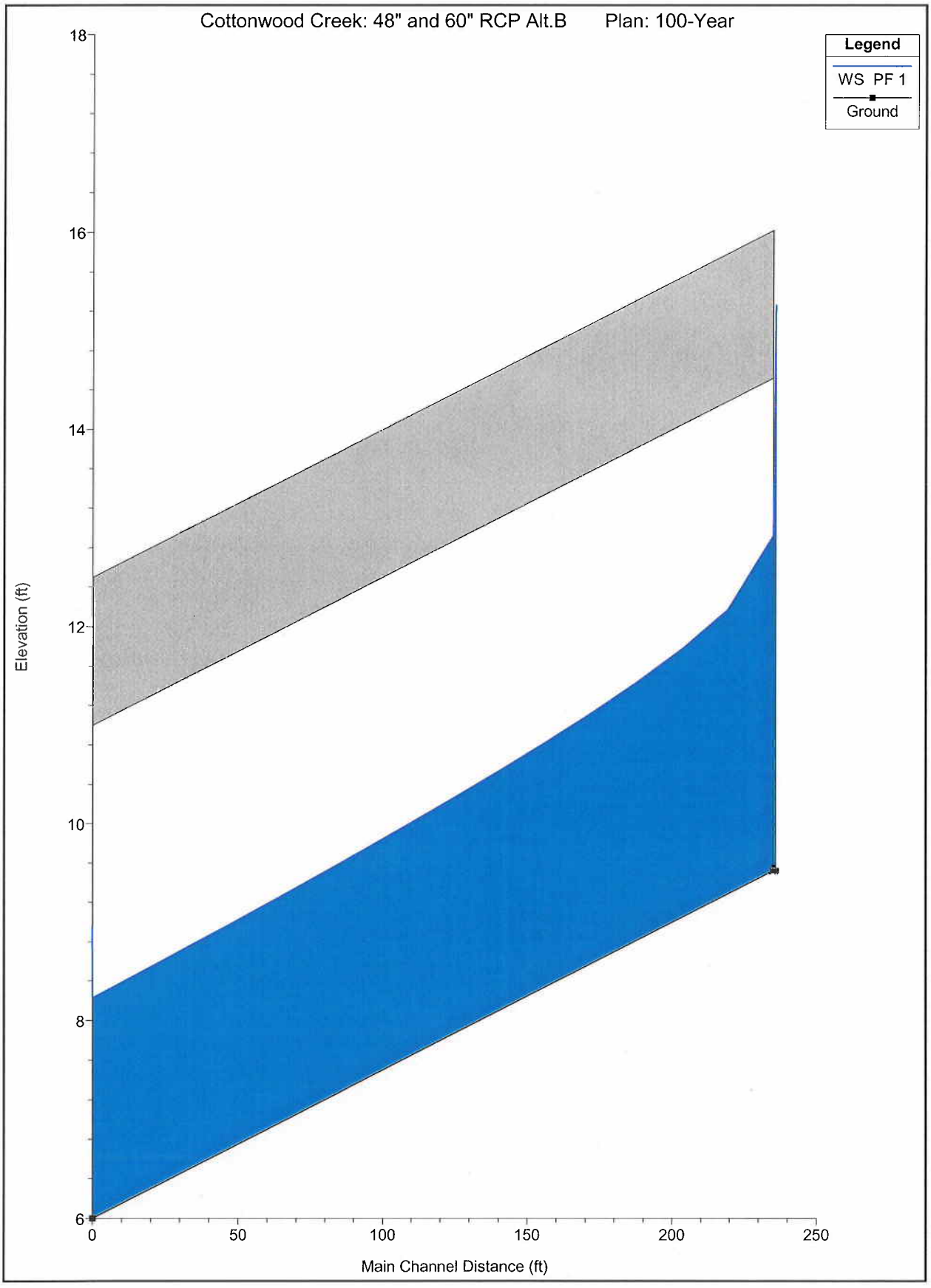

Cottonwood Creek: 48" and 60" RCP Alt.A
Plan: 100-Year
Legend
WS PF 1
Ground
Elevation (ft)
18
16
14
12
10
8
6
0
50
100
150
200
250
Main Channel Distance (ft)

Alternative B: 16' x 5' Conspan Bridge

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Ocean Outfall Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ocean Outfall	2	PF 1	580.00	9.52	15.26	12.48	15.66	0.001852	5.05	114.84	20.00	0.37
Ocean Outfall	1.5		Culvert									
Ocean Outfall	1	PF 1	580.00	6.00	8.96	8.96	10.45	0.013061	9.81	59.12	20.00	1.01

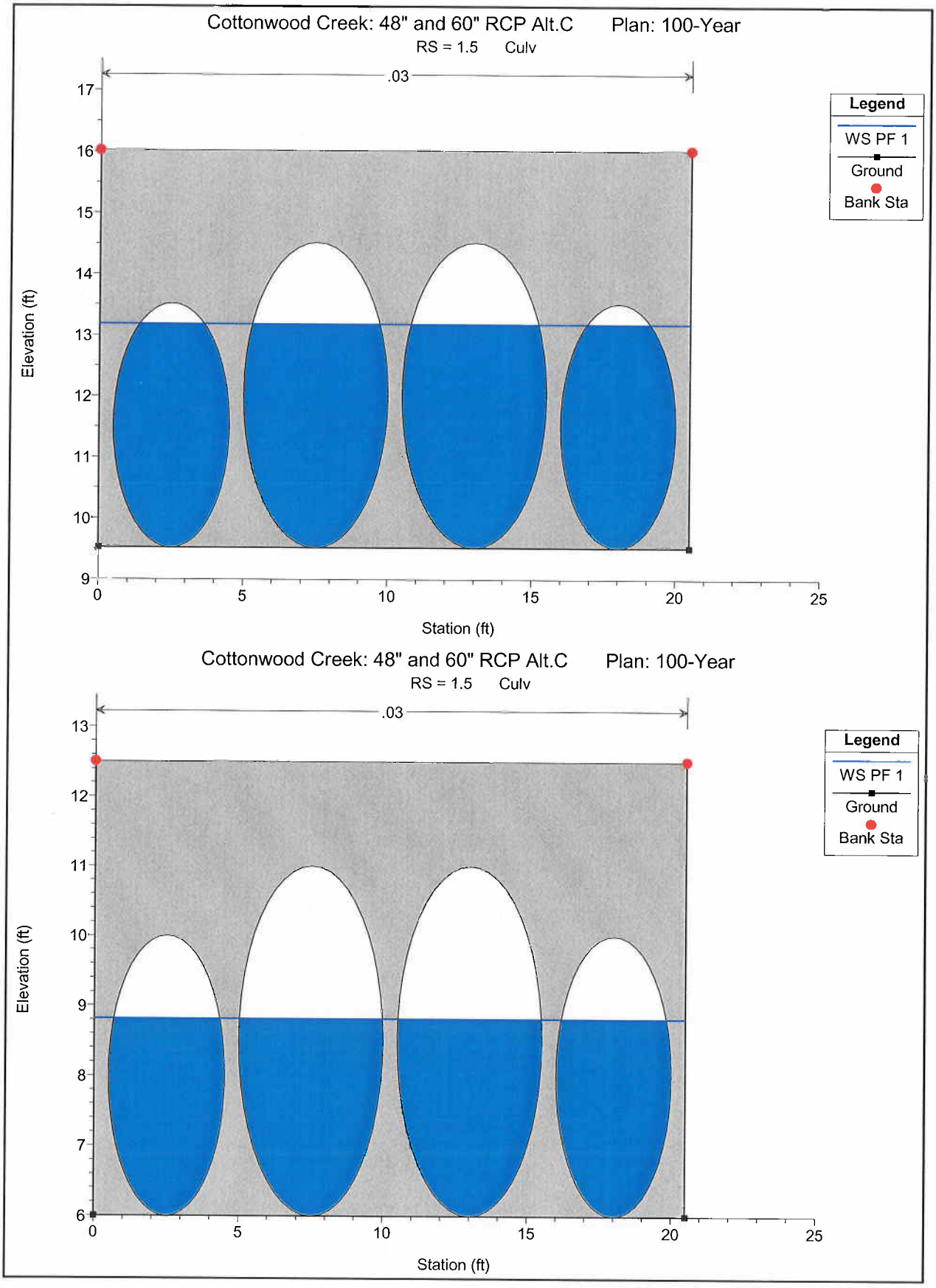

Cottonwood Creek: 48" and 60" RCP Alt.B Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
17
16
15
14
13
12
11
10
9
0
5
10
15
20
Cottonwood Creek: 48" and 60" RCP Alt.B Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
13
12
11
10
9
8
7
6
0
5
10
15
20

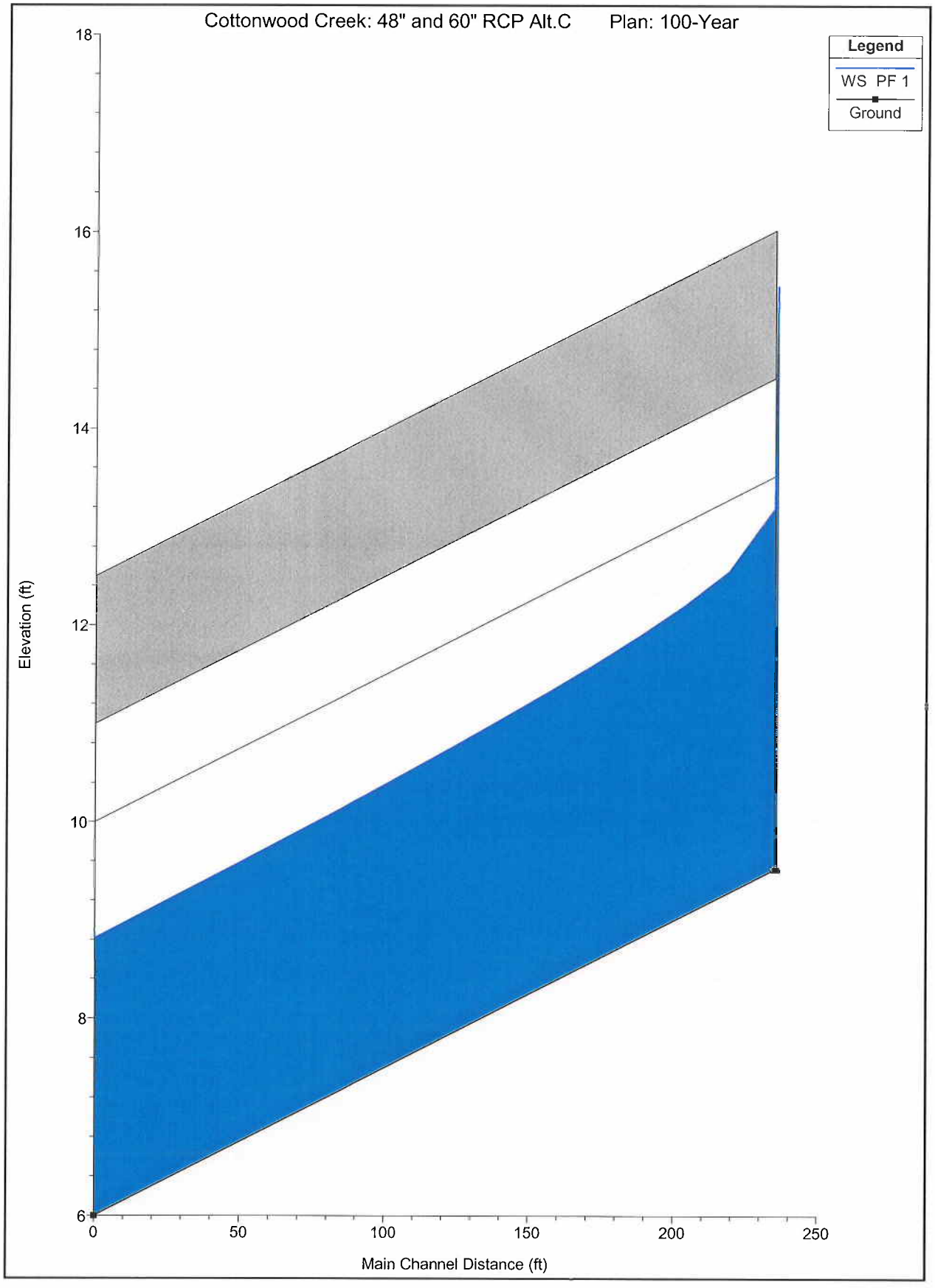

Cottonwood Creek: 48" and 60" RCP Alt.B
Plan: 100-Year
Legend
WS PF 1
Ground
Elevation (ft)
18
16
14
12
10
8
6
0
50
100
150
200
250
Main Channel Distance (ft)

Alternative C: 2- 60" RCP and 48" RCP

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Ocean Outfall Profile: PF 1

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
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ocean Outfall	2	PF 1	580.00	9.52	15.45	12.43	15.80	0.001588	4.77	121.60	20.50	0.35
Ocean Outfall	1.5		Culvert									
Ocean Outfall	1	PF 1	580.00	6.00	8.91	8.91	10.38	0.012972	9.73	59.61	20.50	1.01


Cottonwood Creek: 48" and 60" RCP Alt.C Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
17
16
15
14
13
12
11
10
9
0
5
10
15
20
25
Cottonwood Creek: 48" and 60" RCP Alt.C Plan: 100-Year
RS = 1.5 Culv
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
13
12
11
10
9
8
7
6
0
5
10
15
20
25


Cottonwood Creek: 48" and 60" RCP Alt.C
Plan: 100-Year
Legend
WS PF 1
Ground
Elevation (ft)
18
16
14
12
10
8
6
0
50
100
150
200
250
Main Channel Distance (ft)

APPENDIX D

PROPOSED FOURTH STREET STORM DRAIN SYSTEM

4th Street Curb Inlets
Worksheet for Curb Inlet On Grade

Project Description	
Worksheet	4th Street Inlets
Type	Curb Inlet On Gr
Solve For	Efficiency

Input Data		
Discharge	50.00	cfs
Slope	007000	ft/ft
Gutter Width	1.33	ft
Gutter Cross Slope	093750	ft/ft
Road Cross Slope	020000	ft/ft
Mannings Coefficie	0.017	
Curb Opening Len	65.00	ft
Local Depression	4.0	in
Local Depression \	4.00	ft

Results		
Efficiency	1.00	
Intercepted Flow	50.00	cfs
Bypass Flow	0.00	cfs
Spread	34.04	ft
Depth	0.78	ft
Flow Area	11.7	ft²
Gutter Depression	1.2	in
Total Depression	5.2	in
Velocity	4.29	ft/s
Equivalent Cross Slo	032136	ft/ft
Length Factor	1.02	
Total Interception Ler	63.50	ft

Stormwater Main
Worksheet for Circular Channel

Project Description	
Worksheet	4th Street Mair
Flow Element	Circular Chann
Method	Manning's For
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	
Slope	113000	ft/ft
Diameter	36	in
Discharge	100.00	cfs

Results		
Depth	1.40	ft
Flow Area	3.2	ft²
Wetted Perime	4.52	ft
Top Width	2.99	ft
Critical Depth	2.90	ft
Percent Full	46.8	%
Critical Slope	0.019680	ft/ft
Velocity	30.81	ft/s
Velocity Head	14.75	ft
Specific Energ	16.16	ft
Froude Numbe	5.22	
Maximum Disc	241.17	cfs
Discharge Full	224.20	cfs
Slope Full	0.022481	ft/ft
Flow Type	Supercritical	

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APPENDIX E
SITE PHOTOGRAPHS

Looking downstream at double 6' x 4' RCB that passes under Third Street

Looking downstream at triple 6'-8" x 5' CMPA

Looking downstream at 10' x 4' RCB that passes under B Street

Looking downstream at 60" and 48" RCP

Looking upstream at triple 6'-8" x 5' CMPA

Looking upstream at 60" and 48" RCP