Kimley»Horn

Attachment B – Hydraulic Analysis

Worksheet for XS-1D (Sta 5+20.25)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00520	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Results

Normal Depth	3.07	ft
Flow Area	166.41	ft^2
Wetted Perimeter	67.29	ft
Hydraulic Radius	2.47	ft
Top Width	66.53	ft
Critical Depth	2.53	ft
Critical Slope	0.01035	ft/ft
Velocity	6.53	ft/s
Velocity Head	0.66	ft
Specific Energy	3.73	ft
Froude Number	0.73	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.07	ft
Critical Depth	2.53	ft
Channel Slope	0.00520	ft/ft

Worksheet for XS-1D (Sta 5+20.25)

GVF Output Data

Critical Slope	0.01035	ft/ft

Cross Section for XS-1D (Sta 5+20.25)

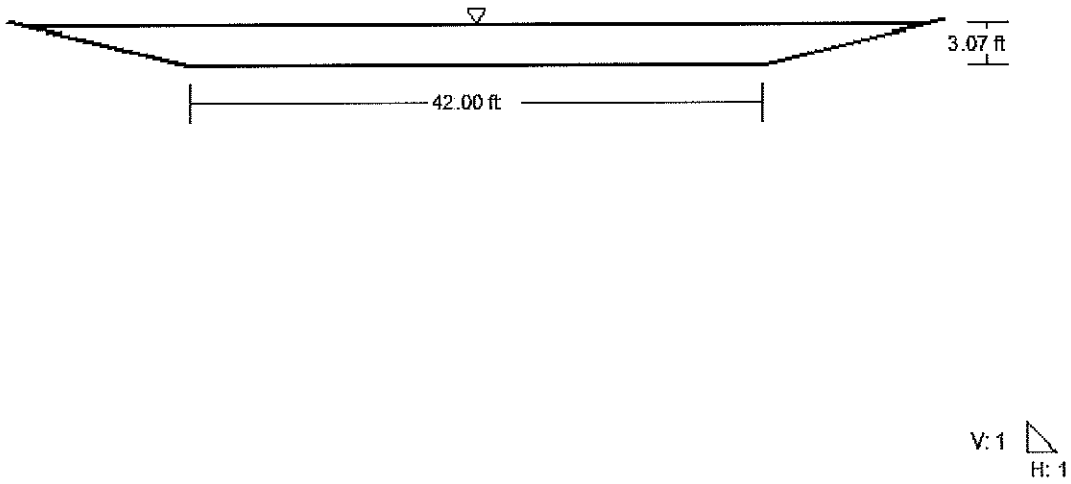
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00520	ft/ft
Normal Depth	3.07	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Cross Section Image



Worksheet for XS-2D (Sta 8+28.41)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00520	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Results

Normal Depth	3.07	ft
Flow Area	166.41	ft^2
Wetted Perimeter	67.29	ft
Hydraulic Radius	2.47	ft
Top Width	66.53	ft
Critical Depth	2.53	ft
Critical Slope	0.01035	ft/ft
Velocity	6.53	ft/s
Velocity Head	0.66	ft
Specific Energy	3.73	ft
Froude Number	0.73	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.07	ft
Critical Depth	2.53	ft
Channel Slope	0.00520	ft/ft

Worksheet for XS-2D (Sta 8+28.41)

GVF Output Data

Critical Slope	0.01035	ft/ft

Cross Section for XS-2D (Sta 8+28.41)

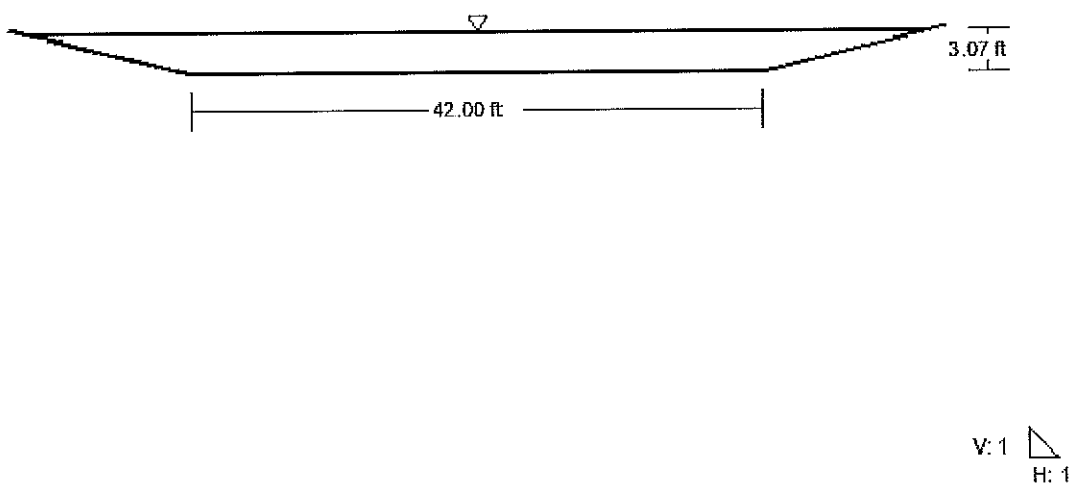
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00520	ft/ft
Normal Depth	3.07	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Cross Section Image



Worksheet for XS-3D (Sta 14+25.86)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00910	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Results

Normal Depth	2.62	ft
Flow Area	137.57	ft^2
Wetted Perimeter	63.61	ft
Hydraulic Radius	2.16	ft
Top Width	62.97	ft
Critical Depth	2.53	ft
Critical Slope	0.01035	ft/ft
Velocity	7.90	ft/s
Velocity Head	0.97	ft
Specific Energy	3.59	ft
Froude Number	0.94	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.62	ft
Critical Depth	2.53	ft
Channel Slope	0.00910	ft/ft

Worksheet for XS-3D (Sta 14+25.86)

GVF Output Data

Critical Slope	0.01035	ft/ft

Cross Section for XS-3D (Sta 14+25.86)

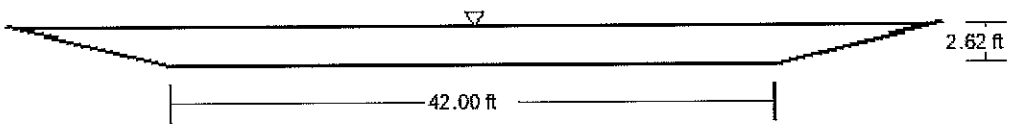
Project Description

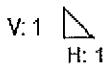
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00910	ft/ft
Normal Depth	2.62	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Cross Section Image





Worksheet for XS-4D (Sta 21+15.05)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Results

Normal Depth	3.10	ft
Flow Area	168.66	ft^2
Wetted Perimeter	67.57	ft
Hydraulic Radius	2.50	ft
Top Width	66.80	ft
Critical Depth	2.53	ft
Critical Slope	0.01035	ft/ft
Velocity	6.44	ft/s
Velocity Head	0.65	ft
Specific Energy	3.75	ft
Froude Number	0.72	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.10	ft
Critical Depth	2.53	ft
Channel Slope	0.00500	ft/ft

Worksheet for XS-4D (Sta 21+15.05)

GVF Output Data

Critical Slope	0.01035	ft/ft

Cross Section for XS-4D (Sta 21+15.05)

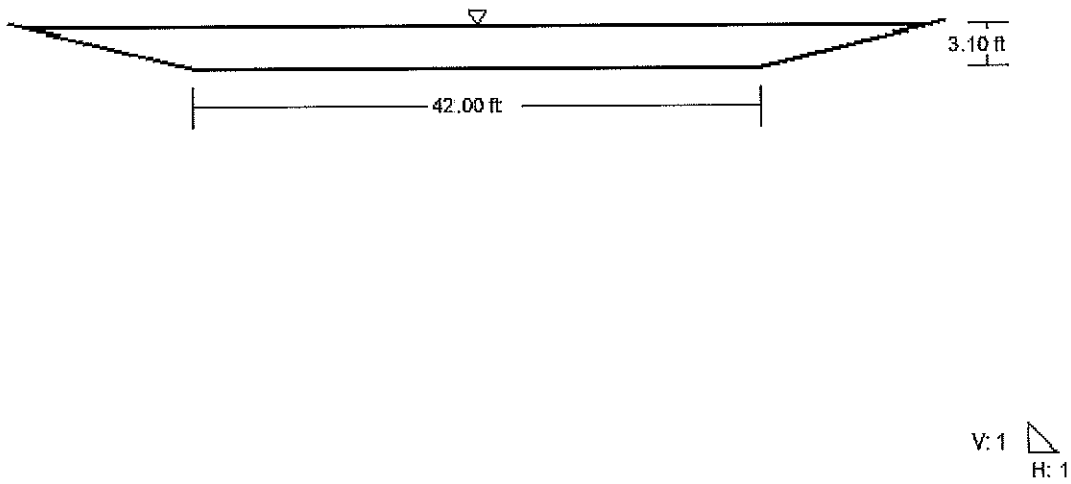
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	3.10	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Cross Section Image



Worksheet for XS-5D (Sta 27+13.68)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00910	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Results

Normal Depth	2.62	ft
Flow Area	137.57	ft^2
Wetted Perimeter	63.61	ft
Hydraulic Radius	2.16	ft
Top Width	62.97	ft
Critical Depth	2.53	ft
Critical Slope	0.01035	ft/ft
Velocity	7.90	ft/s
Velocity Head	0.97	ft
Specific Energy	3.59	ft
Froude Number	0.94	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.62	ft
Critical Depth	2.53	ft
Channel Slope	0.00910	ft/ft

Worksheet for XS-5D (Sta 27+13.68)

GVF Output Data

Critical Slope	0.01035	ft/ft

Cross Section for XS-5D (Sta 27+13.68)

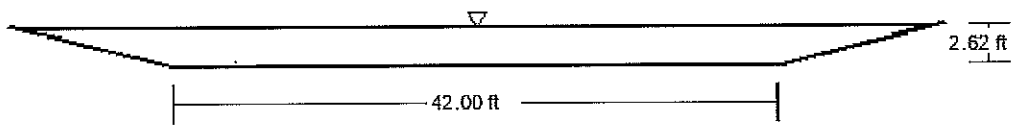
Project Description

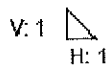
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00910	ft/ft
Normal Depth	2.62	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	42.00	ft
Discharge	1087.00	ft^3/s

Cross Section Image





Worksheet for XS-1E (Sta 5+20.25)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00670	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+41	1024.85
0+63	1019.79
0+75	1019.76
0+91	1019.71
1+10	1019.61
1+26	1023.37

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+41, 1024.85)	(0+63, 1019.79)	0.030
(0+63, 1019.79)	(1+10, 1019.61)	0.040
(1+10, 1019.61)	(1+26, 1023.37)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.12	ft
Elevation Range	1019.61 to 1024.85 ft	
Flow Area	180.39	ft²
Wetted Perimeter	73.79	ft
Hydraulic Radius	2.44	ft

Worksheet for XS-1E (Sta 5+20.25)

Results

Top Width		73.11	ft
Normal Depth		3.12	ft
Critical Depth		2.48	ft
Critical Slope		0.01567	ft/ft
Velocity		6.03	ft/s
Velocity Head		0.56	ft
Specific Energy		3.68	ft
Froude Number		0.68	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.12	ft
Critical Depth	2.48	ft
Channel Slope	0.00670	ft/ft
Critical Slope	0.01567	ft/ft

Cross Section for XS-1E (Sta 5+20.25)

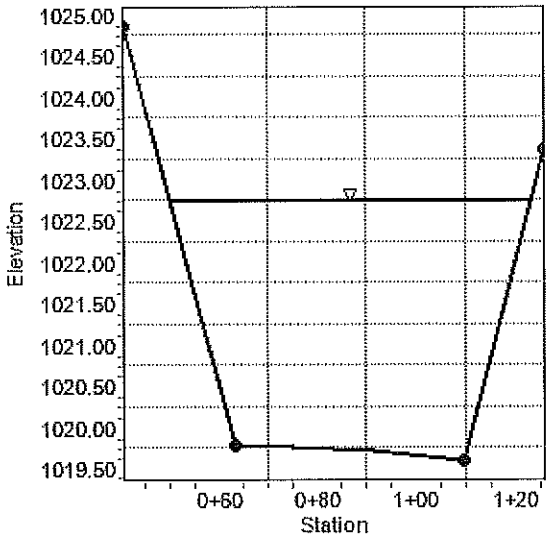
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00670	ft/ft
Normal Depth	3.12	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for XS-2E (Sta 8+28.41)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00650	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+49	1021.20
0+68	1017.41
0+84	1017.12
1+10	1017.02
1+27	1021.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+49, 1021.20)	(0+68, 1017.41)	0.030
(0+68, 1017.41)	(1+10, 1017.02)	0.040
(1+10, 1017.02)	(1+27, 1021.50)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.34	ft
Elevation Range	1017.02 to 1021.50 ft	
Flow Area	177.31	ft²
Wetted Perimeter	70.09	ft
Hydraulic Radius	2.53	ft
Top Width	69.37	ft

Worksheet for XS-2E (Sta 8+28.41)

Results

Normal Depth		3.34	ft
Critical Depth		2.66	ft
Critical Slope		0.01518	ft/ft
Velocity		6.13	ft/s
Velocity Head		0.58	ft
Specific Energy		3.92	ft
Froude Number		0.68	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.34	ft
Critical Depth	2.66	ft
Channel Slope	0.00650	ft/ft
Critical Slope	0.01518	ft/ft

Cross Section for XS-2E (Sta 8+28.41)

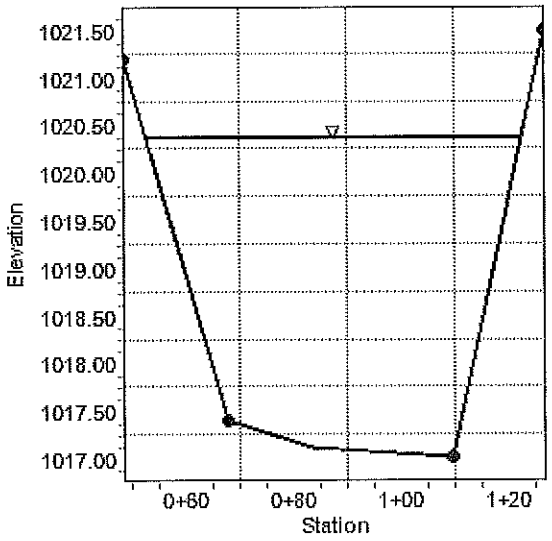
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00650	ft/ft
Normal Depth	3.34	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for XS-3E (Sta 14+25.86)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+60	1015.21
0+76	1011.78
0+99	1012.00
1+20	1012.21
1+38	1016.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+60, 1015.21)	(0+76, 1011.78)	0.030
(0+76, 1011.78)	(1+20, 1012.21)	0.045
(1+20, 1012.21)	(1+38, 1016.00)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.30	ft
Elevation Range	1011.78 to 1016.00 ft	
Flow Area	181.48	ft²
Wetted Perimeter	73.49	ft
Hydraulic Radius	2.47	ft
Top Width	72.82	ft

Worksheet for XS-3E (Sta 14+25.86)

Results

Normal Depth		3.30	ft
Critical Depth		2.63	ft
Critical Slope		0.01842	ft/ft
Velocity		5.99	ft/s
Velocity Head		0.56	ft
Specific Energy		3.86	ft
Froude Number		0.67	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.30	ft
Critical Depth	2.63	ft
Channel Slope	0.00770	ft/ft
Critical Slope	0.01842	ft/ft

Cross Section for XS-3E (Sta 14+25.86)

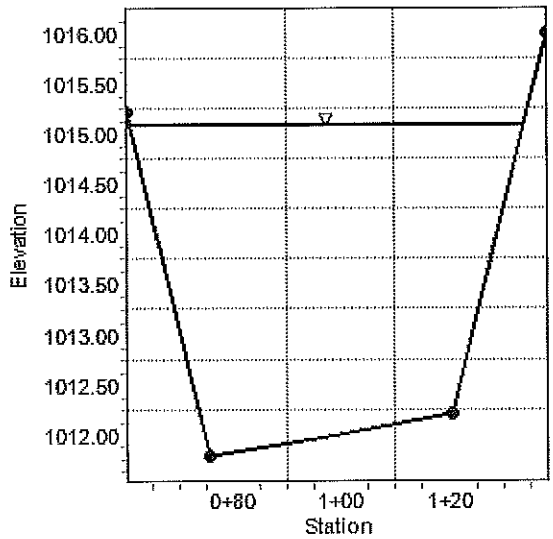
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Normal Depth	3.30	ft
Discharge	1087.00	ft^3/s

Cross Section Image



Worksheet for XS-4E (Sta 21+15.05)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00660	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+40	1010.38
0+53	1007.36
0+55	1006.73
0+62	1006.84
0+75	1006.96
0+98	1007.16
1+01	1007.89
1+14	1011.36

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+40, 1010.38)	(0+55, 1006.73)	0.030
(0+55, 1006.73)	(0+98, 1007.16)	0.045
(0+98, 1007.16)	(1+14, 1011.36)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.57	ft
Elevation Range	1006.73 to 1011.36 ft	
Flow Area	186.64	ft²

Worksheet for XS-4E (Sta 21+15.05)

Results

Wetted Perimeter		70.07	ft
Hydraulic Radius		2.66	ft
Top Width		69.23	ft
Normal Depth		3.57	ft
Critical Depth		2.74	ft
Critical Slope		0.01828	ft/ft
Velocity		5.82	ft/s
Velocity Head		0.53	ft
Specific Energy		4.09	ft
Froude Number		0.63	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.57	ft
Critical Depth	2.74	ft
Channel Slope	0.00660	ft/ft
Critical Slope	0.01828	ft/ft

Cross Section for XS-4E (Sta 21+15.05)

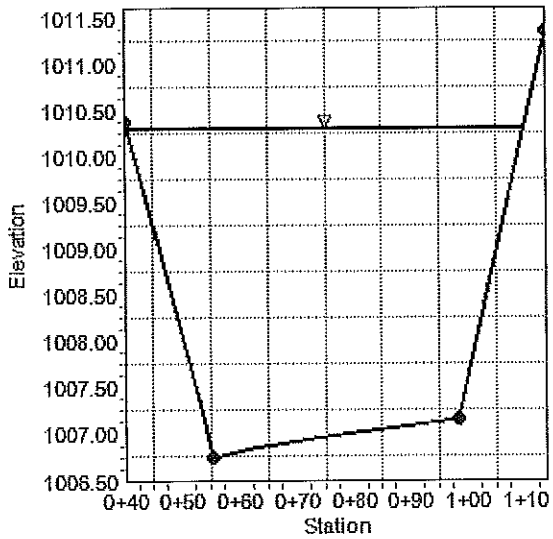
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00660	ft/ft
Normal Depth	3.57	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for XS-5E (Sta 27+13.68)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+65	1005.69
0+74	1003.21
0+77	1002.46
1+14	1002.63
1+22	1002.69
1+26	1003.58
1+39	1007.12

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+65, 1005.69)	(0+77, 1002.46)	0.030
(0+77, 1002.46)	(1+22, 1002.69)	0.040
(1+22, 1002.69)	(1+39, 1007.12)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.08	ft
Elevation Range	1002.46 to 1007.12 ft	
Flow Area	167.09	ft²
Wetted Perimeter	68.30	ft

Worksheet for XS-5E (Sta 27+13.68)

Results

Hydraulic Radius		2.45	ft
Top Width		67.54	ft
Normal Depth		3.08	ft
Critical Depth		2.55	ft
Critical Slope		0.01569	ft/ft
Velocity		6.51	ft/s
Velocity Head		0.66	ft
Specific Energy		3.73	ft
Froude Number		0.73	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.08	ft
Critical Depth	2.55	ft
Channel Slope	0.00790	ft/ft
Critical Slope	0.01569	ft/ft

Cross Section for XS-5E (Sta 27+13.68)

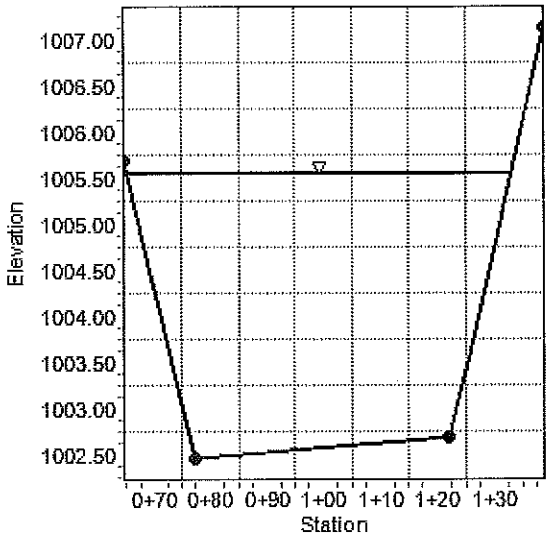
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Normal Depth	3.08	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #1 - XS-1PF - 9" (Sta 5+20.25)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00670	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+41	1024.85
0+57	1019.61
0+75	1019.61
0+91	1019.61
1+15	1019.61
1+26	1023.37

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+41, 1024.85)	(0+57, 1019.61)	0.058
(0+57, 1019.61)	(1+15, 1019.61)	0.058
(1+15, 1019.61)	(1+26, 1023.37)	0.058

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.58	ft
Elevation Range	1019.61 to 1024.85 ft	
Flow Area	246.20	ft²
Wetted Perimeter	80.59	ft
Hydraulic Radius	3.05	ft

Worksheet for Alternative #1 - XS-1PF - 9" (Sta 5+20.25)

Results

Top Width		79.42	ft
Normal Depth		3.58	ft
Critical Depth		2.14	ft
Critical Slope		0.03980	ft/ft
Velocity		4.42	ft/s
Velocity Head		0.30	ft
Specific Energy		3.89	ft
Froude Number		0.44	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.58	ft
Critical Depth	2.14	ft
Channel Slope	0.00670	ft/ft
Critical Slope	0.03980	ft/ft

Cross Section for Alternative #1 - XS-1PF - 9" (Sta 5+20.25)

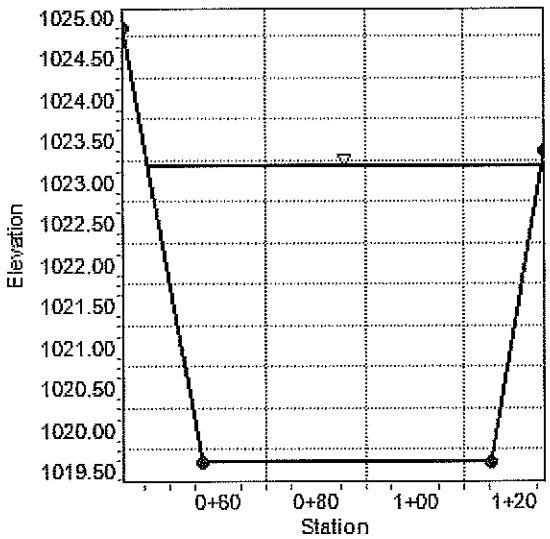
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00670	ft/ft
Normal Depth	3.58	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #1 - XS-2PF -18" (Sta 8+28.41)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00650	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+49	1021.20
0+62	1017.02
0+84	1017.02
1+14	1017.02
1+27	1021.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+49, 1021.20)	(0+62, 1017.02)	0.077
(0+62, 1017.02)	(1+14, 1017.02)	0.077
(1+14, 1017.02)	(1+27, 1021.50)	0.077

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	4.48	ft
Elevation Range	1017.02 to 1021.50 ft	
Flow Area	293.19	ft²
Wetted Perimeter	79.71	ft
Hydraulic Radius	3.68	ft
Top Width	78.00	ft

Worksheet for Alternative #1 - XS-2PF -18" (Sta 8+28.41)

Results

Normal Depth		4.48	ft
Critical Depth		2.28	ft
Critical Slope		0.06913	ft/ft
Velocity		3.71	ft/s
Velocity Head		0.21	ft
Specific Energy		4.69	ft
Froude Number		0.34	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	4.48	ft
Critical Depth	2.28	ft
Channel Slope	0.00650	ft/ft
Critical Slope	0.06913	ft/ft

Cross Section for Alternative #1 - XS-2PF -18" (Sta 8+28.41)

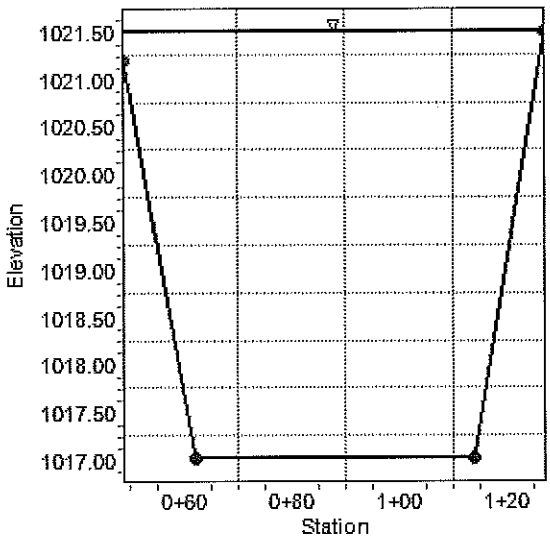
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00650	ft/ft
Normal Depth	4.48	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #1 - XS-3PF - 9" (Sta 14+25.86)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+60	1015.21
0+70	1011.78
0+99	1011.78
1+25	1011.78
1+38	1016.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+60, 1015.21)	(0+70, 1011.78)	0.058
(0+70, 1011.78)	(1+25, 1011.78)	0.058
(1+25, 1011.78)	(1+38, 1016.00)	0.058

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.54	ft
Elevation Range	1011.78 to 1016.00 ft	
Flow Area	232.03	ft²
Wetted Perimeter	77.14	ft
Hydraulic Radius	3.01	ft
Top Width	75.90	ft

Worksheet for Alternative #1 - XS-3PF - 9" (Sta 14+25.86)

Results

Normal Depth		3.54	ft
Critical Depth		2.20	ft
Critical Slope		0.03951	ft/ft
Velocity		4.68	ft/s
Velocity Head		0.34	ft
Specific Energy		3.88	ft
Froude Number		0.47	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.54	ft
Critical Depth	2.20	ft
Channel Slope	0.00770	ft/ft
Critical Slope	0.03951	ft/ft

Cross Section for Alternative #1 - XS-3PF - 9" (Sta 14+25.86)

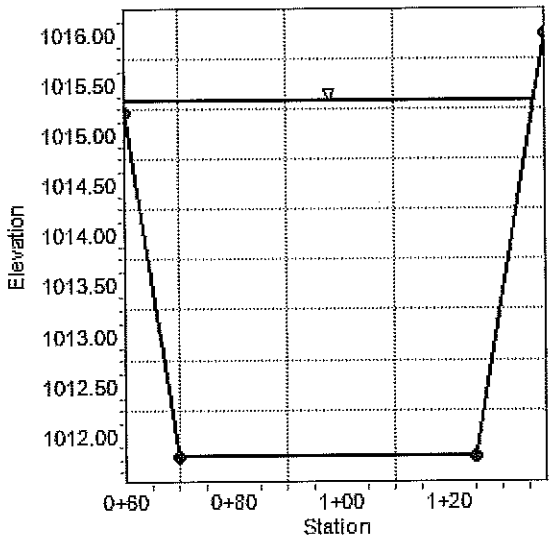
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Normal Depth	3.54	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #1 - XS-4PF - 9" (Sta 21+15.05)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00660	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+40	1010.38
0+51	1006.73
0+62	1006.73
0+75	1006.73
1+00	1006.73
1+14	1011.36

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+40, 1010.38)	(1+14, 1011.36)	0.056

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.84	ft
Elevation Range	1006.73 to 1011.36 ft	
Flow Area	232.77	ft²
Wetted Perimeter	73.02	ft
Hydraulic Radius	3.19	ft
Top Width	71.62	ft
Normal Depth	3.84	ft

Worksheet for Alternative #1 - XS-4PF - 9" (Sta 21+15.05)

Results

Critical Depth		2.36	ft
Critical Slope		0.03629	ft/ft
Velocity		4.67	ft/s
Velocity Head		0.34	ft
Specific Energy		4.18	ft
Froude Number		0.46	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.84	ft
Critical Depth	2.36	ft
Channel Slope	0.00660	ft/ft
Critical Slope	0.03629	ft/ft

Cross Section for Alternative #1 - XS-4PF - 9" (Sta 21+15.05)

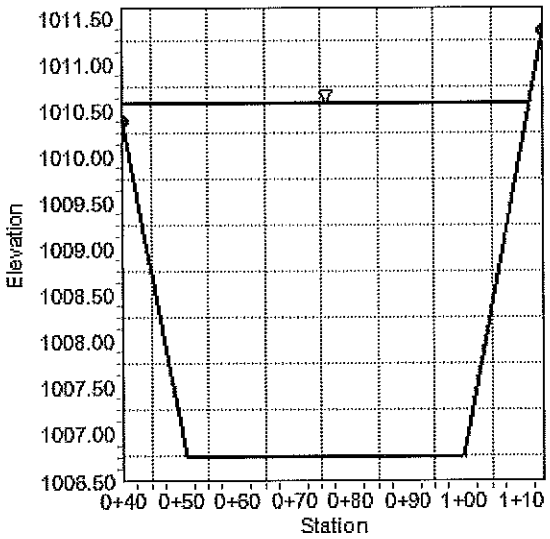
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00660	ft/ft
Normal Depth	3.84	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #1 - XS-5PF - 9" (Sta 27+13.68)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+65	1005.69
0+75	1002.46
1+14	1002.46
1+22	1002.46
1+25	1002.46
1+39	1007.12

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+65, 1005.69)	(1+39, 1007.12)	0.058

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.68	ft
Elevation Range	1002.46 to 1007.12 ft	
Flow Area	224.74	ft²
Wetted Perimeter	72.60	ft
Hydraulic Radius	3.10	ft
Top Width	71.04	ft
Normal Depth	3.68	ft

Worksheet for Alternative #1 - XS-5PF - 9" (Sta 27+13.68)

Results

Critical Depth		2.33	ft
Critical Slope		0.03904	ft/ft
Velocity		4.84	ft/s
Velocity Head		0.36	ft
Specific Energy		4.04	ft
Froude Number		0.48	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.68	ft
Critical Depth	2.33	ft
Channel Slope	0.00790	ft/ft
Critical Slope	0.03904	ft/ft

Cross Section for Alternative #1 - XS-5PF - 9" (Sta 27+13.68)

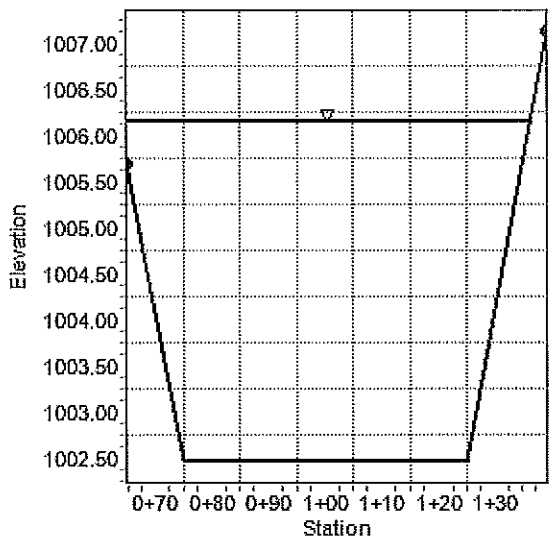
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Normal Depth	3.68	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #2 - XS-1PH - 9" (Sta 5+20.25)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00670	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+41	1024.85
0+57	1019.61
0+75	1019.61
0+91	1019.61
1+15	1019.61
1+26	1023.37

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+41, 1024.85)	(0+57, 1019.61)	0.058
(0+57, 1019.61)	(1+15, 1019.61)	0.030
(1+15, 1019.61)	(1+26, 1023.37)	0.058

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	2.83	ft
Elevation Range	1019.61 to 1024.85 ft	
Flow Area	187.76	ft²
Wetted Perimeter	75.82	ft
Hydraulic Radius	2.48	ft

Worksheet for Alternative #2 - XS-1PH - 9" (Sta 5+20.25)

Results

Top Width		74.90	ft
Normal Depth		2.83	ft
Critical Depth		2.14	ft
Critical Slope		0.01750	ft/ft
Velocity		5.79	ft/s
Velocity Head		0.52	ft
Specific Energy		3.35	ft
Froude Number		0.64	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.83	ft
Critical Depth	2.14	ft
Channel Slope	0.00670	ft/ft
Critical Slope	0.01750	ft/ft

Cross Section for Alternative #2 - XS-1PH - 9" (Sta 5+20.25)

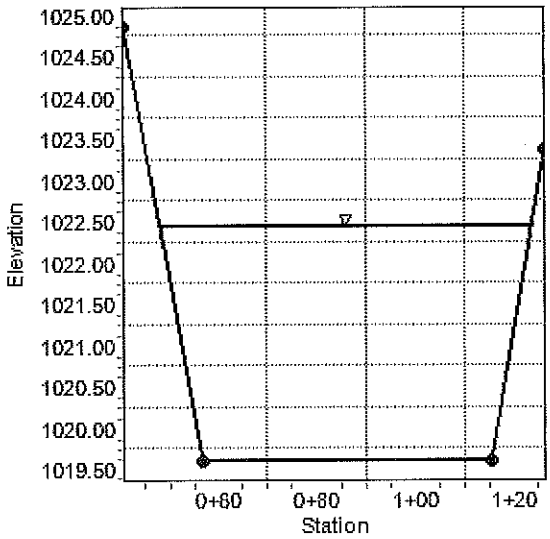
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00670	ft/ft
Normal Depth	2.83	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #2 - XS-2PH - 18" (Sta 8+28.41)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00650	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+49	1021.20
0+62	1017.02
0+84	1017.02
1+14	1017.02
1+27	1021.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+49, 1021.20)	(0+62, 1017.02)	0.077
(0+62, 1017.02)	(1+14, 1017.02)	0.030
(1+14, 1017.02)	(1+27, 1021.50)	0.077

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.47	ft
Elevation Range	1017.02 to 1021.50 ft	
Flow Area	216.86	ft²
Wetted Perimeter	74.01	ft
Hydraulic Radius	2.93	ft
Top Width	72.88	ft

Worksheet for Alternative #2 - XS-2PH - 18" (Sta 8+28.41)

Results

Normal Depth		3.47	ft
Critical Depth		2.28	ft
Critical Slope		0.02793	ft/ft
Velocity		5.01	ft/s
Velocity Head		0.39	ft
Specific Energy		3.86	ft
Froude Number		0.51	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.47	ft
Critical Depth	2.28	ft
Channel Slope	0.00650	ft/ft
Critical Slope	0.02793	ft/ft

Cross Section for Alternative #2 - XS-2PH - 18" (Sta 8+28.41)

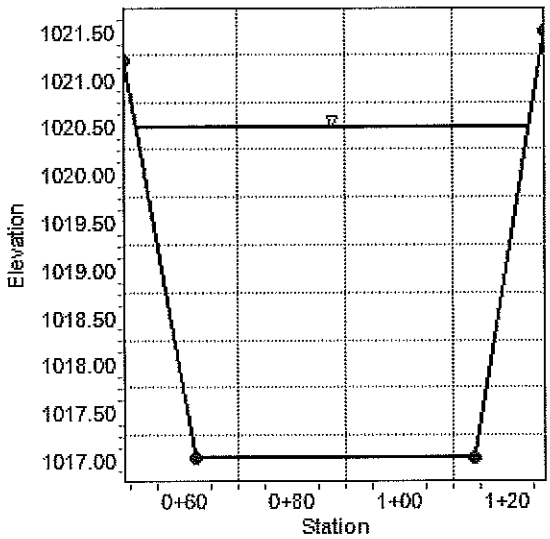
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00650	ft/ft
Normal Depth	3.47	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #2 - XS-3PH - 9" (Sta 14+25.86)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+60	1015.21
0+70	1011.78
0+99	1011.78
1+25	1011.78
1+38	1016.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+60, 1015.21)	(0+70, 1011.78)	0.058
(0+70, 1011.78)	(1+25, 1011.78)	0.030
(1+25, 1011.78)	(1+38, 1016.00)	0.058

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	2.81	ft
Elevation Range	1011.78 to 1016.00 ft	
Flow Area	177.90	ft²
Wetted Perimeter	72.73	ft
Hydraulic Radius	2.45	ft
Top Width	71.82	ft

Worksheet for Alternative #2 - XS-3PH - 9" (Sta 14+25.86)

Results

Normal Depth		2.81	ft
Critical Depth		2.20	ft
Critical Slope		0.01763	ft/ft
Velocity		6.11	ft/s
Velocity Head		0.58	ft
Specific Energy		3.39	ft
Froude Number		0.68	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.81	ft
Critical Depth	2.20	ft
Channel Slope	0.00770	ft/ft
Critical Slope	0.01763	ft/ft

Cross Section for Alternative #2 - XS-3PH - 9" (Sta 14+25.86)

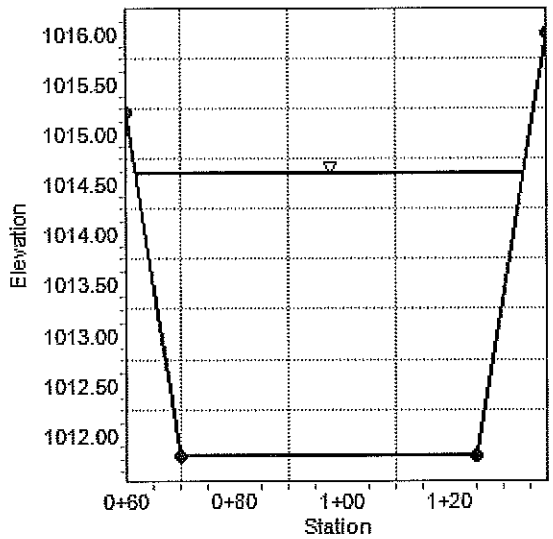
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Normal Depth	2.81	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #2 - XS-4PH - 9" (Sta 21+15.05)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00660	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+40	1010.38
0+51	1006.73
0+62	1006.73
0+75	1006.73
1+00	1006.73
1+14	1011.36

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+40, 1010.38)	(0+51, 1006.73)	0.056
(0+51, 1006.73)	(1+00, 1006.73)	0.030
(1+00, 1006.73)	(1+14, 1011.36)	0.056

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	3.15	ft
Elevation Range	1006.73 to 1011.36 ft	
Flow Area	184.18	ft²
Wetted Perimeter	69.02	ft
Hydraulic Radius	2.67	ft

Worksheet for Alternative #2 - XS-4PH - 9" (Sta 21+15.05)

Results

Top Width		68.01	ft
Normal Depth		3.15	ft
Critical Depth		2.36	ft
Critical Slope		0.01792	ft/ft
Velocity		5.90	ft/s
Velocity Head		0.54	ft
Specific Energy		3.69	ft
Froude Number		0.63	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.15	ft
Critical Depth	2.36	ft
Channel Slope	0.00660	ft/ft
Critical Slope	0.01792	ft/ft

Cross Section for Alternative #2 - XS-4PH - 9" (Sta 21+15.05)

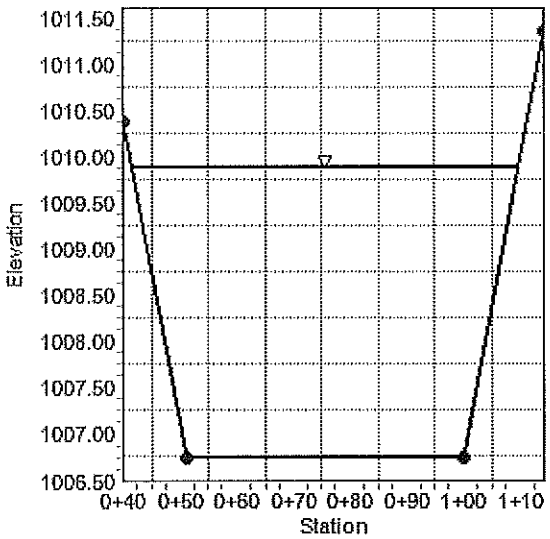
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00660	ft/ft
Normal Depth	3.15	ft
Discharge	1087.00	ft³/s

Cross Section Image



Worksheet for Alternative #2 - XS-5PH - 9" (Sta 27+13.68)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Discharge	1087.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+65	1005.69
0+75	1002.46
1+14	1002.46
1+22	1002.46
1+25	1002.46
1+39	1007.12

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+65, 1005.69)	(0+75, 1002.46)	0.058
(0+75, 1002.46)	(1+25, 1002.46)	0.030
(1+25, 1002.46)	(1+39, 1007.12)	0.058

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	2.97	ft
Elevation Range	1002.46 to 1007.12 ft	
Flow Area	175.67	ft²
Wetted Perimeter	69.09	ft
Hydraulic Radius	2.54	ft

Worksheet for Alternative #2 - XS-5PH - 9" (Sta 27+13.68)

Results

Top Width		68.14	ft
Normal Depth		2.97	ft
Critical Depth		2.33	ft
Critical Slope		0.01835	ft/ft
Velocity		6.19	ft/s
Velocity Head		0.60	ft
Specific Energy		3.57	ft
Froude Number		0.68	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.97	ft
Critical Depth	2.33	ft
Channel Slope	0.00790	ft/ft
Critical Slope	0.01835	ft/ft

Cross Section for Alternative #2 - XS-5PH - 9" (Sta 27+13.68)

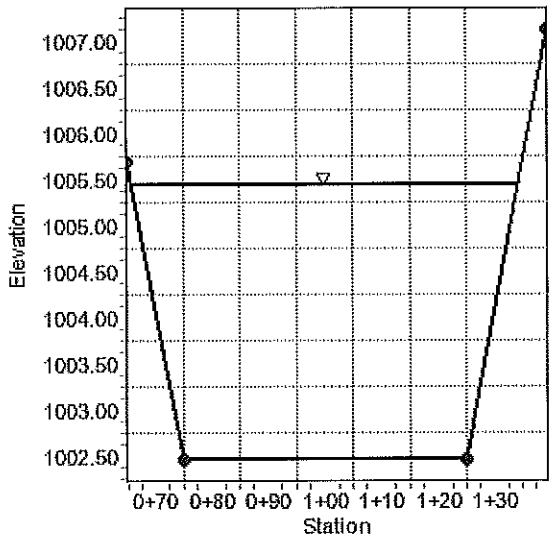
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00790	ft/ft
Normal Depth	2.97	ft
Discharge	1087.00	ft³/s

Cross Section Image



Flood Control District of Maricopa County

Drainage Design Manual

for Maricopa County, Arizona

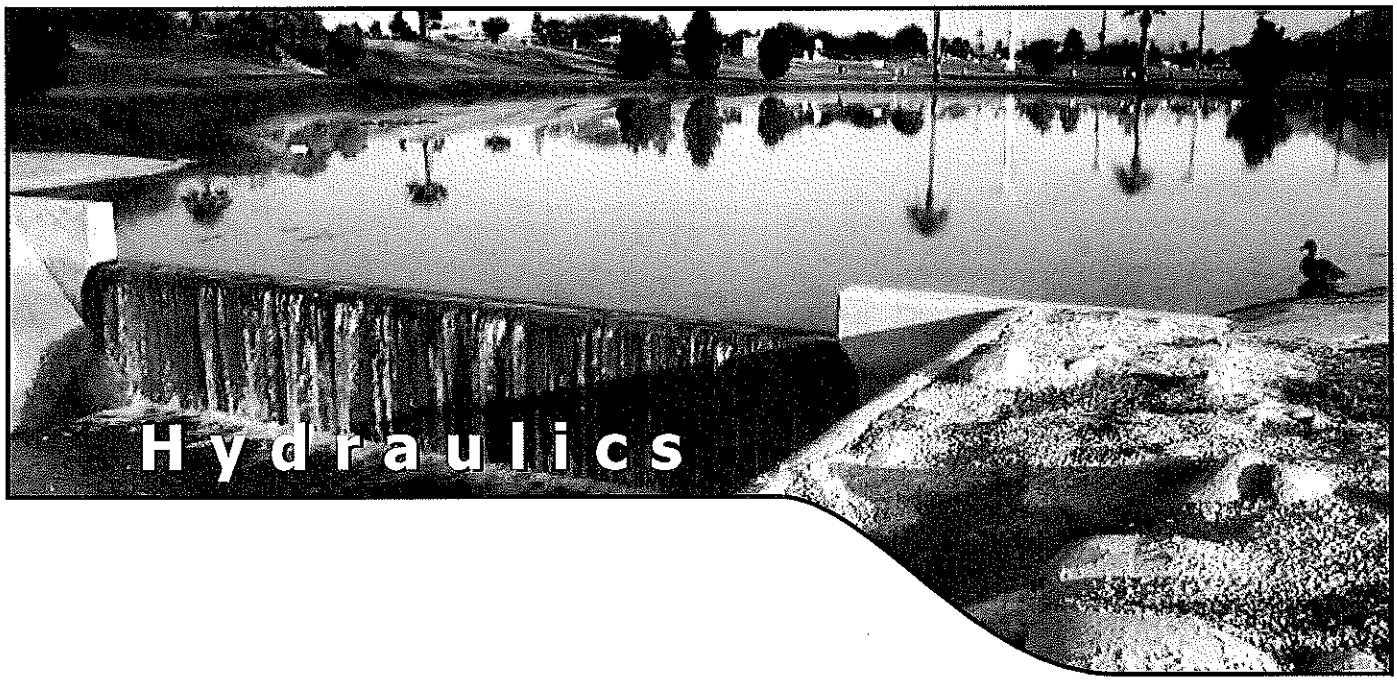


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TABLE 7.2
BASE VALUES OF n FOR UPPER-REGIME FLOWS IN SAND CHANNELS
[Modified from Benson and Dalrymple (1967)]

Median Size of Bed Material (mm)	Base n-value
0.2	0.012
0.3	0.017
0.4	0.020
0.5	0.022
0.6	0.023
0.8	0.025
1.0	0.026

7.6.2 Base Values of *n* for Stable Channels

A stable channel is defined as a channel in which the bed is composed of firm earth, gravel, cobbles, boulders, or bedrock and remains relatively unchanged through most of the range in flow (Aldridge and Garrett, 1973). Base n-values for stable channels have been determined mainly from field-verification studies. Base n-values for firm earth, gravel, cobble, and boulder channels can be selected by visually comparing the characteristics with those of channels that have known or verified coefficients (Barnes, 1967; Aldridge and Garrett, 1973; Phillips and Ingersoll, 1998), by comparing measured size of bed material with verified values of Manning's *n* (Table 7.3), or by use of equations derived from channel and hydraulic parameters and verified values of Manning's *n*. Base n-values for bedrock channels can be selected by visual comparison with bedrock channels where Manning's *n* has been verified.

TABLE 7.3
BASE VALUES OF MANNING'S n FOR CHANNELS CONSIDERED STABLE

Channel Type	Median Size of Bed Material		Base n-value	
	Millimeters	Inches	Benson and Dalrymple (1967)	Chow (1959)
Firm earth	---	---	0.025–0.032	0.020
Coarse sand	1–2	---	0.026–0.035	---
Fine gravel	---	---	---	0.024
Gravel	2–64	0.08–2.5	0.028–0.035	---
Coarse gravel	---	---	---	0.028

TABLE 7.4
ADJUSTMENT FACTORS OR COMPONENT RANGES FOR VARIOUS CHANNEL CONDITIONS
Used to Determine Manning's n-values

(Adjustment to degree of meandering values apply to flow confined in the channel and does not apply where flow crosses meanders; Modified from Cowen, 1956; and Chow, 1959.)

Channel Conditions	Manning's n Adjustment	Example
Severe	0.040–0.060	Obst[illegible] ross section area, [illegible] ll enough to caus[illegible] .
Amount of vegetation		
Negligible	0.000–0.002	Gras[illegible] over during flow.
Small	0.002–0.010	Dense growths of flexible turf grass, such as Bermuda, or weeds growing where the average depth of flow is at least two times the height of the vegetation where the vegetation is not laid over. Trees, such as willow, cottonwood, or saltcedar, growing where the average depth of flow is at least three times the height of the vegetation. Flow depth is about two times the tree height, and the trees are laid over.
Medium	0.010–0.025	Moderately dense grass, weeds, or tree seedlings growing where the average depth of flow is from two to three times the height of vegetation; brushy, moderately dense vegetation, similar to 1- to 2-year-old willow trees growing along the banks. A few 8 to 10-year old willow, cottonwood, mesquite, or palo verde, which blocks flow by approximately 1 to 10 percent, and spheres of influence or turbulence do not overlap.
Large	0.025–0.050	[illegible] esquite or palo verde [illegible] 30 percent where the [illegible] wn with some weeds [illegible] ceeds 2 feet.
Very large	0.050–0.100	[illegible] ntergrown with weeds alongside slopes or dense cattails growing along the channel bottom; trees intergrown with weeds and brush. Moderately dense (blocks flow by approximately 30 to 50 percent and the sphere's of influence overlap) 8- to 10-year old trees spaced randomly throughout channel where depth of flow approximates height of vegetation.

A Manning's n adjustment factor of 0.015 was applied to the design Manning's n value of 0.030 for the bottom of the channel for XS-1, XS-2, and XS-5 in the existing conditions model due to the growth of vegetation.

A Manning's n adjustment factor of 0.015 was applied to the design Manning's n value of 0.030 for the bottom of the channel for XS-3 and XS-4 in the existing conditions model due to the growth of vegetation.

TABLE 7.6
COMPOSITE VALUES OF n FOR STABLE CONSTRUCTED CHANNELS

Type of Channel and Description	n-value[1]		
	Minimum	**Normal**	**Maximum**
c. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050

1.Excerpt from: Simons, Li and Associates (1981). Adapted from Chow (1959), Aldridge and Garret (1973), and USDOT (2005).

TABLE 7.7
COMPOSITE MANNING'S n-VALUES FOR ROCK RIPRAP LINED CHANNELS
Source: USDOT (2005), page 6-1, equation 6.1

Average Flow Depth (A/T) (ft)	d_{50} (in)									
	Cobble		Riprap							
	2.5	**3.0**	**5.0**	**6.0**	**9.0**	**12.0**	**15.0**	**18.0**	**21.0**	**24.0**
1.0				0.069	n/a	n/a	n/a	n/a	n/a	n/a
1.5				0.059	0.073	0.088	n/a	n/a	n/a	n/a
2.0	0.040	0.042	0.051	0.054	0.066	0.077	0.089	n/a	n/a	n/a
2.5	0.039	0.041	0.048	0.052	0.061	0.070	0.080	0.090	n/a	n/a
3.0	0.038	0.040	0.047	0.050	0.058	0.066	0.074	0.082	0.091	0.099
3.5	0.037	0.039	0.046	0.048	0.056	0.063	0.070	0.077	0.084	0.092
4.0	0.037	0.039	0.045	0.047	0.055	0.061	0.067	0.074	0.080	0.086
4.5	0.036	0.038	0.044	0.046	0.053	0.059	0.065	0.071	0.077	0.082
5.0	0.036	0.038	0.043	0.046	0.052	0.058	0.063	0.069	0.074	0.079
5.5	0.036	0.038	0.043	0.045	0.051	0.057	0.062	0.067	0.072	0.077
6.0	0.036	0.037	0.043	0.045	0.051	0.056	0.061	0.065	0.070	0.074

Proposed conditions
Manning's n values

where:

A = cross sectional area of channel at flow depth,

T = channel top width at flow depth.