Third Street Bridge over Broomalls Run
Media Borough, Delaware County

DRAINAGE DESIGN COMPUTATIONS

Prepared for:

Borough of Media
301 N. Jackson Street
Media, PA 19380

Prepared by:

LARSON DESIGN GROUP
901 Dawn Avenue
Ephrata, PA 17522
717-721-9008

Project No. 5887-002

April 29, 2011

DRAINAGE NARRATIVE

THIRD STREET BRIDGE DAM
OVER BROOMALLS RUN

Project Description:

This proposed project involves replacing the existing spillway of the Third Street Dam in Media Borough, Delaware County. The spillway carries Third Street over Broomalls Run between Kirk Lane and West Street.

The project includes removal of the existing spillway structure and replacing the reinforced concrete bridge slab with a precast concrete box culvert. Additionally, the existing earth retaining walls on the downstream side of the dam will be removed and fill we be placed and graded along the dam toe to provide slope stability. A steel sheet pile wall is proposed along the upstream side of the roadway to make room for a pedestrian walkway between Broomalls Lake and Third Street.

The proposed storm sewer system was analyzed using Bentley FlowMaster. FlowMaster utilizes the methodology of HEC-12 and HEC-22 to determine grate efficiencies and pipe loss coefficients. The Rational Method was used to determine the flow rates for the drainage areas. Runoff coefficients for the Rational Method were obtained from the PennDOT Drainage Manual (PUB 584) Table 7.6.

Proposed drainage systems were designed to meet the more stringent regulations of PennDOT Design Manual Part 2 (DM-2), Chapter 10 and the Media Borough Stormwater Management ordinance. In this case, the Borough ordinance and PennDOT regulations are very similar. PennDOT design criteria is referenced in the Borough Ordinance, however, the particular references have since been updated. As such, current PennDOT regulations were followed during design. The design year storm for the drainage system is specified as being 10-year in PennDOT DM-2 Chapter 10.

Preliminary Drainage Design:

The proposed drainage was developed to meet the PennDOT DM-2 requirements and the Media Borough ordinance. The project is separate from the existing drainage system located east of the project in Media Borough. The roadway has a sag vertical curve over the dam with the low point approximately 65 feet from the proposed box culvert. The inlets east of the bridge were inventoried to determine their contribution of flow to the project location.

A site visit was made to the project and the Media Borough. Limits for the contributing drainage area were determined and more than 20 inlets were identified in this area as being able to intercepts surface runoff before reaching the project location. The inlet types were identified

and photos were taken of each one (see **Appendix B**). Conservative values for inlet intercept were used to develop a conservative flow that would reach the proposed drainage system.

The initial inlet placement was based on DM-2, Chapter 10 criteria which states that an inlet must be placed at the low point of a sag vertical curve with two inlets flanking on either side at no more than a maximum distance of 100 feet from the low point or at grade not greater than 0.20 feet above the sag inlet. The 0.20 feet above the sag inlet criteria was used for this project for the flanking inlets. A fourth inlet was added approximately 96 feet further west of the western flanking drain to assist in the large flows coming from Kirk Lane. A fifth inlet was added approximately 61 feet east of the east flanking drain on the downstream side of the dam only, to help deal with the flows coming from Media Borough. The proposed inlet configuration therefore involves using four drains on the upstream side and five inlets on the downstream side of Third Street for a total of nine proposed inlets. Each upstream inlet has a pipe running from it to the corresponding downstream inlet, which in turn have pipes running towards a riser box appurtenant to the proposed spillway culvert. Flows received at the riser box will pass into the spillway culvert and merge with flows from Broomalls Lake.

Stormwater Summary:

The design of the stormwater system for Third Street over the dam will meet the applicable design standards as presented within this narrative. A concerted effort was made to not over-design the system from the District's preferred design storms while still meeting the local ordinances. Drainage area maps, computations and plans are presented in the following sections for the design of this stormwater system.

Appendix A

TABLE 10.3.5
ALTERNATE PIPE SELECTION CRITERIA BASED UPON LOCATION OF DRAINAGE PIPES

LOCATION OF DRAINAGE PIPES		TYPES OF PIPE		NO. OF ALTERNATES REQUIRED
Cross Drains Under Pavement, Shoulder, or Between Curbs; Parallel Storm Sewers Under Pavement or Between Curbs	Fill*	Interstate/ Arterials	Collectors/ Locals	2
	< 0.6 m (< 2 ft)	100 Years Life (Pipes 1, 2, 5 & 7)	50 Years Life (Pipes 1 & 3 thru 7)	
	0.6 m - 4.6 m (2 ft - 15 ft)	100 Years Life (Pipes 1, 2, 5 & 7)	50 Years Life (Pipes 1 & 3 thru 7 & 8)	
	> 4.6 m (> 15 ft)	100 Years Life (Pipes 1, 2, 5 & 7)	100 Years Life (Pipes 1, 2, 5 & 7)	
Parallel Storm Sewers Outside of Pavement or Curbs	50 Years Life (All pipes in LEGEND)			3
Cross Drains Outside of Pavement, Shoulder or Curbs (Cross Drains in Medians, etc.)	50 Years Life (All pipes in LEGEND except 9)			3
Combination Storm Sewer and Underdrain and Other Special Drainage System	100 Years Life•	Pipe 2, open joint, & perforated pipes 5 & 7		2
	50 Years Life••	Fill * < 0.6 m (2 ft)	Pipe 3, open joint, & perforated pipes 4, 5 & 7	3
		Fill * ≥ 0.6 m (2 ft)	Pipe 3, open joint, & perforated pipes 4, 5, 7 & 8	
Slope Pipes	50 Years Life (Pipes 4 thru 9)			2
Side Drains (Driveways, etc.)	25 Years Life (All pipes in LEGEND)			3

Separate tables are provided for fill height requirements. Utilize those tables for determination of minimum and maximum fill requirements. Specified minimum fill heights are applicable to pipes under pavement or between curbs. Specified maximum fill heights are applicable to all installations.

* Fill is defined as the material from the top of the pipe to the riding surface, including the pavement structure.
• For pipes under pavement or between curbs on Interstate/Arterials.
•• For pipes other than under pavement or between curbs on Interstate/Arterials.

LEGEND
(Types of Pipe)

1. DIP = Ductile Iron Pipe.
2. RCP (Type A) = Reinforced Concrete Pipe, heavy duty.
3. RCP (Type B) = Reinforced Concrete Pipe, normal duty (1200 mm (48 in) max).
4. CGSP = Corrugated Galvanized Steel Pipe.
5. CASP = Corrugated Aluminized Steel Pipe.
6. CCGSP = Coated (Polymer) Corrugated Galvanized Steel Pipe.
7. CAAP = Corrugated Aluminum Alloy Pipe.
8. TP (Group I, II, III, IV or VI) = Thermoplastic Pipe, Group I, II, III, IV or VI (1500 mm (60 in) max). Thermoplastic Pipe Groups are defined in Publication 408, *Specifications,* Section 601.
9. TP (Group V - Corr PE) = Thermoplastic Pipe, Group V - Corrugated Polyethylene (900 mm (36 in) max). Thermoplastic Pipe Groups are defined in Publication 408, *Specifications,* Section 601.

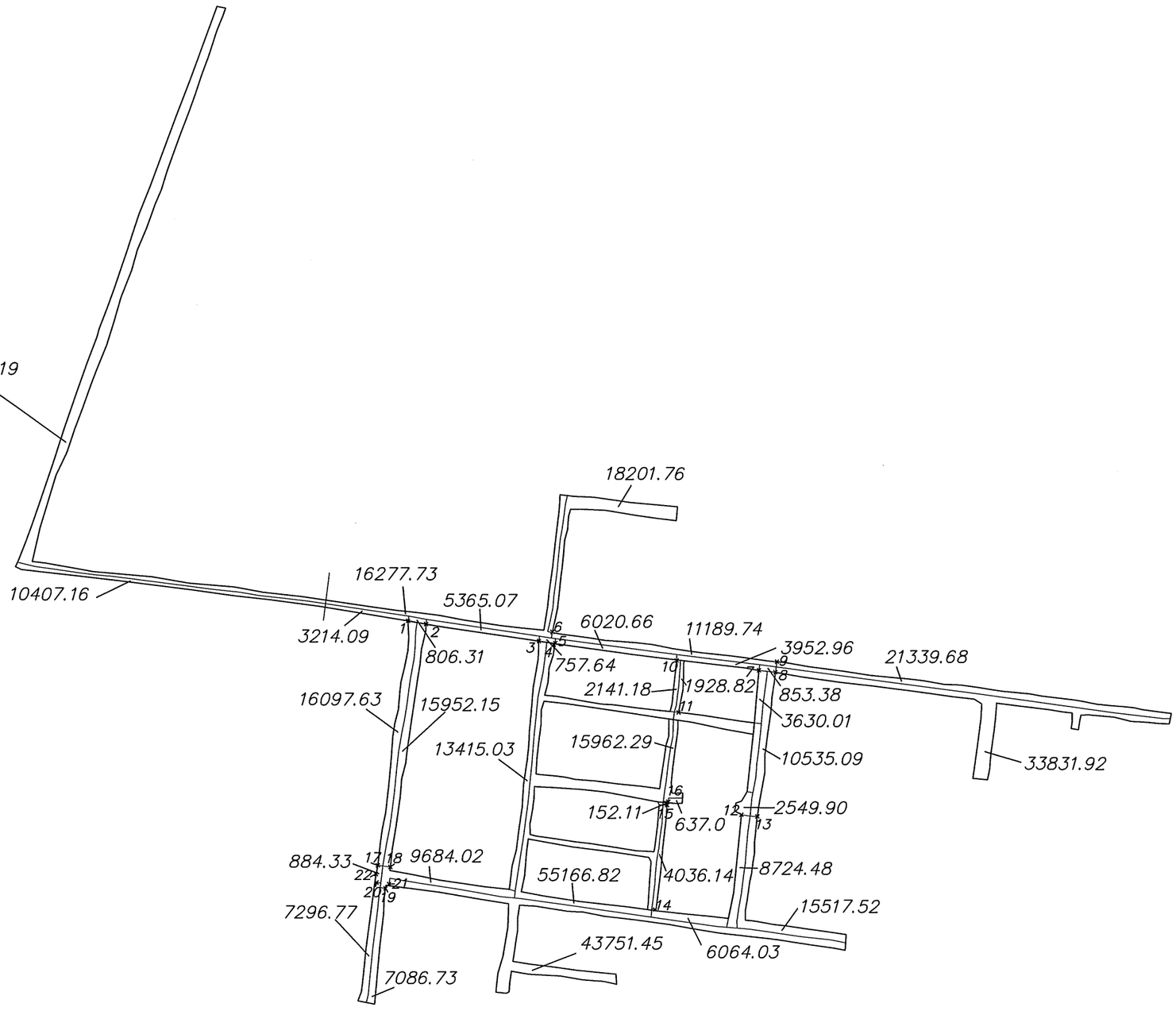
NOTES:

1. Select pipes with specified years life based on the type of drainage installation, class of highway and fill height (cover). The years life indicated (100, 50 and 25) are approximate expected service lives.

2. Pipe alternates may be eliminated for the following reasons: (1) unstable support, (2) high impact and concentrated loading, (3) high embankments, (4) limited clearance, (5) steep gradients, (6) high acidity to alkalinity of soils and water or other corrosive elements, (7) high erosive forces or (8) for other pertinent reasons.

Inlets	Areas (sq. ft.)			A = Area (ac)	C = Runoff factor	I = Rate of rainfall (in/h)	Q = Peak discharge (cfs)	Inlet Type	Flow Intercepted (cfs)	Remaining Flow (cfs)
1	806.31	16097.63		0.3881	0.60	6.60	1.537	M	2	0.000
2	5365.07	15952.15		0.4894	0.60	6.60	1.938	M	2	0.000
3	757.64	13415.03		0.3254	0.60	6.60	1.288	C	2	0.000
4	55166.82			1.2665	0.60	6.60	5.015	C	2	3.015
5	6020.66	1928.82	3952.96	0.2732	0.60	6.60	1.082	C	2	0.000
6	18201.76	11189.74		0.6747	0.60	6.60	2.672	C	2	0.672
7	853.38	3630.01		0.1029	0.60	6.60	0.408	M	-	0.408
8	33831.92	10535.09		1.0185	0.60	6.60	4.033	M	2	2.033
9	21339.68			0.4899	0.60	6.60	1.940	M	-	1.940
10	2141.18			0.0492	0.60	6.60	0.195	M	2	0.000
11	15962.29			0.3664	0.60	6.60	1.451	M	2	0.000
12	8724.48			0.2003	0.60	6.60	0.793	C	2	0.000
13	15517.52			0.3562	0.60	6.60	1.411	-	-	1.411
14	6064.03			0.1392	0.60	6.60	0.551	C	2	0.000
15	4036.14			0.0927	0.60	6.60	0.367	C	2	0.000
16	637.00	2549.90	152.11	0.0767	0.60	6.60	0.304	M	2	0.000
17	884.33			0.0203	0.60	6.60	0.080	M	2	0.000
18	9684.02			0.2223	0.60	6.60	0.880	M	2	0.000
19	7086.73			0.1627	0.60	6.60	0.644	M	2	0.000
20	7296.77			0.1675	0.60	6.60	0.663	M	2	0.000
21	43751.45			1.0044	0.60	6.60	3.977	M	2	1.977
22				0.0000	0.60	6.60	0.000	-	-	0.000
U/S	65495.19	16277.73		1.8772	0.60	6.60	7.434	-	-	7.434
D/S	10407.16	3214.09		0.3127	0.60	6.60	1.238	-	-	1.238
			TOTAL:	10.0764			39.902			20.128

								Total
U/S Inlet Flow:	7.434	0.672	1.940					10.046
D/S Inlet Flow:	1.238	3.015	0.408	2.033	1.411	1.977		10.082



Mark	Description	By	Chk'd.	Recm'd	Date
REVISIONS					

S.R. 0194 PREVIOUSLY KNOWN AS LR 190

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

DELAWARE COUNTY
3rd STREET DAM REHABILITATION

OVER BROOMALLS RUN
DRAINAGE DESIGN

RECOMMENDED _____

SHEET __ OF __

S-

DES: MSK	DWG: MSK	CKD: RGS	JOB: 5887-002	DATE: 1/12/11

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JOB 5887-002 3rd Street Dam
SHEET NO. _____ OF _____
CALCULATED BY MSK DATE 3/17/11
CHECKED BY RDS DATE 3/18/11
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Roadway Drainage

- Site visit on 10/21/10 performed to determine limits of drainage area
- Limits mapped in AutoCAD over Google Earth Image of project area and surrounding topography. Drainages then measured in CAD
- Flows for each inlet in drainage area computed in spread sheet using a conservative runoff factor of C=0.60 for suburban areas (Pub 584 Table 7.6)
- Intercepted flow for each inlet conservatively assumed to be 2 cfs (DM-2 Table 10.3.2)
- Total flow at low point of sag curve = 20.13 cfs (8.67 cfs from far side + 11.46 cfs from near side)
- U/S inlet flow = 10.05 cfs D/S inlet flow = 10.08 cfs

Design Assumptions

- Inlets placed at low point of sag curve
- Pipes will drain into precast concrete box culvert.
- Assume pipe will be 18" ϕ
- distance between inlet and culvert wall
  (14+17.59) - (13+55.24+9) = 53.35'
- Slope:
  Minimum slope = 0.35% per DM-2

and other abstractions have a proportionally smaller effect on runoff. The designer should adjust the runoff coefficient by the factor C_f as indicated in Table 7.7. Generally, the product of C and C_f should not exceed 1.0.

Table 7.6 Runoff Factors for the Rational Equation

TYPE OF DRAINAGE AREA OR SURFACE	RUNOFF FACTOR "C"	
	MINIMUM	MAXIMUM
Pavement, concrete or bituminous concrete	0.75	0.95
Pavement, bituminous macadam or surface-treated gravel	0.65	0.80
Pavement, gravel, macadam, etc.	0.25	0.60
Sandy soil, cultivated or light growth	0.15	0.30
Sandy soil, woods or heavy brush	0.15	0.30
Gravel, bare or light growth	0.20	0.40
Gravel, woods or heavy brush	0.15	0.35
Clay soil, bare or light growth	0.35	0.75
Clay soil, woods or heavy growth	0.25	0.60
City business sections	0.60	0.80
Dense residential sections	0.50	0.70
Suburban, normal residential areas	0.35	0.60
Rural areas, parks, golf courses	0.15	0.30

NOTES

1. Higher values are applicable to denser soils and steep slopes.
2. Consideration should be given to future land use changes in the drainage area in selecting the "C" factor.
3. For drainage area containing several different types of ground cover, a weighted value of "C" factor shall be used.
4. In special situations where sinkholes, stripped abandoned mines, etc. exist, careful evaluation shall be given to the selection of a suitable runoff factor with consideration given to possible reclamation of the land in the future.

Figure 7A.14(a) Rainfall Intensity for 1- through 100-year Storms for Region 4 (U.S. Customary).

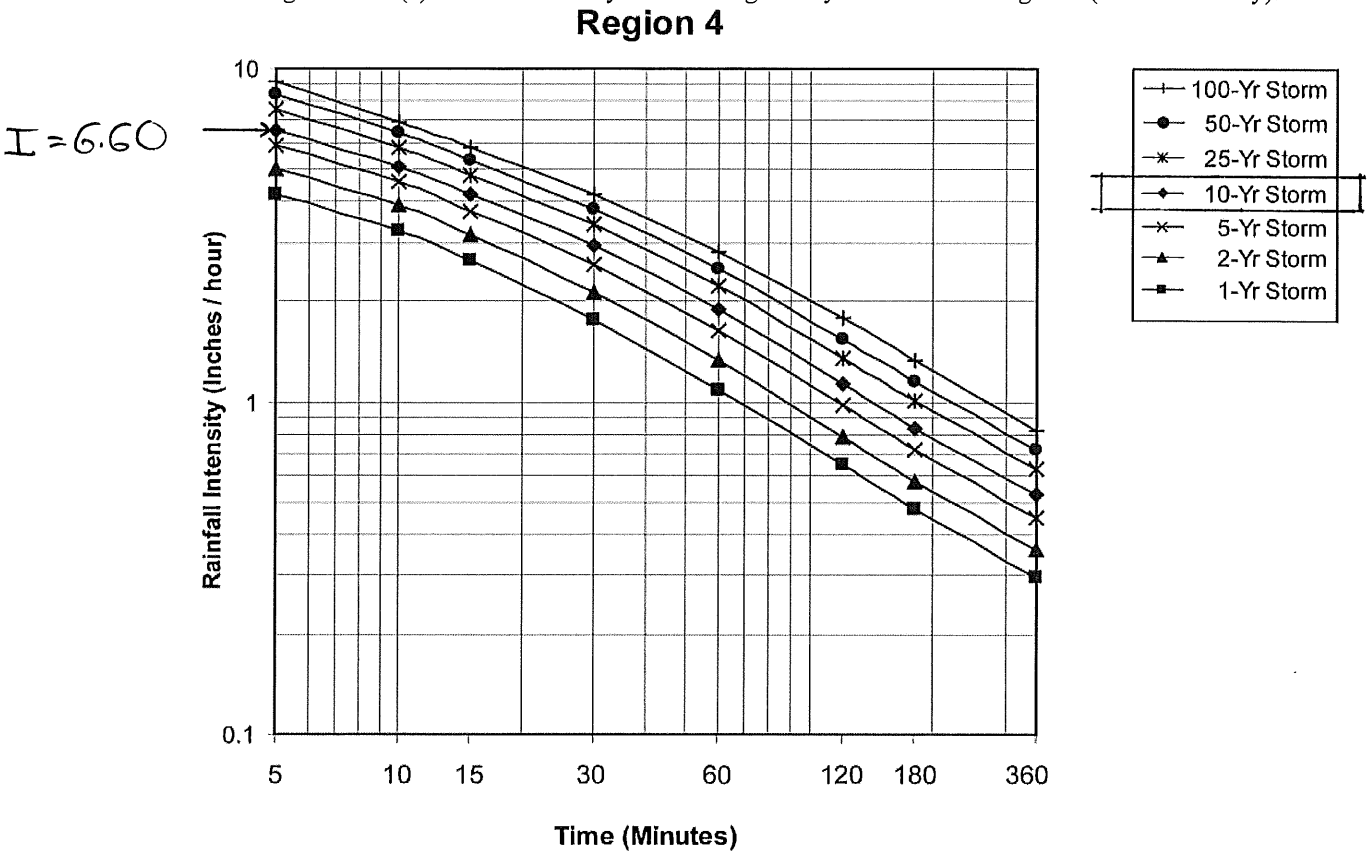


Figure 7A.14(b) Rainfall Amount for 1- through 100-year Storms for Region 4 (U.S. Customary).

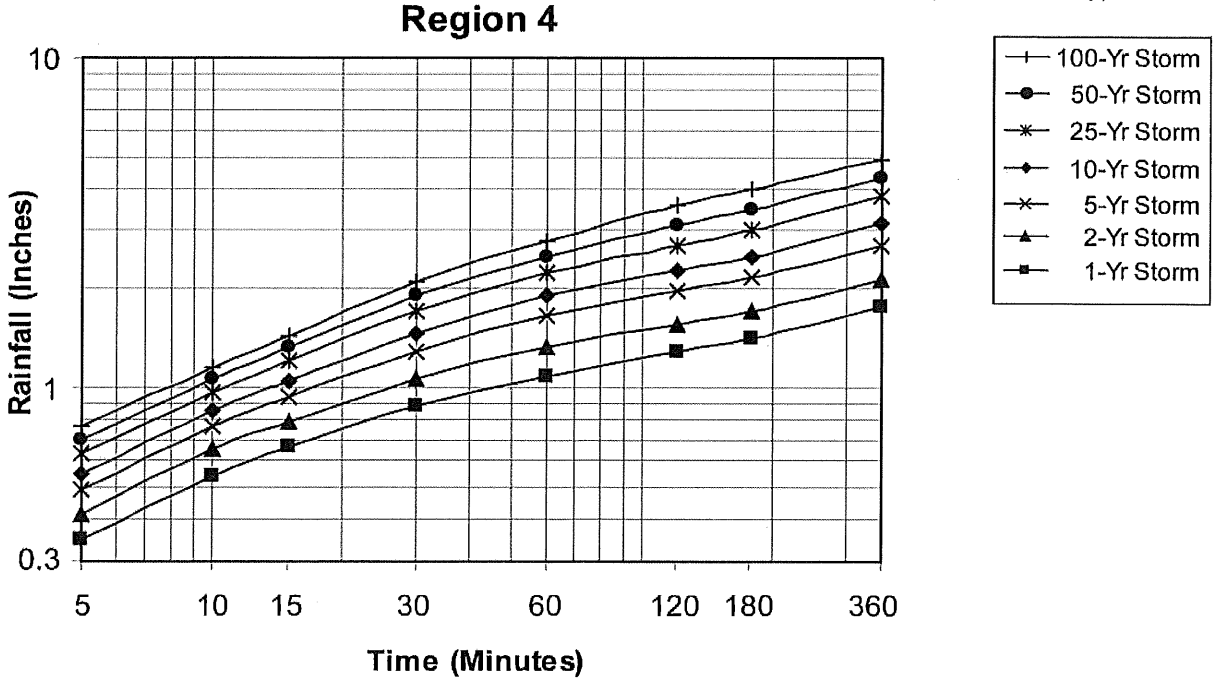
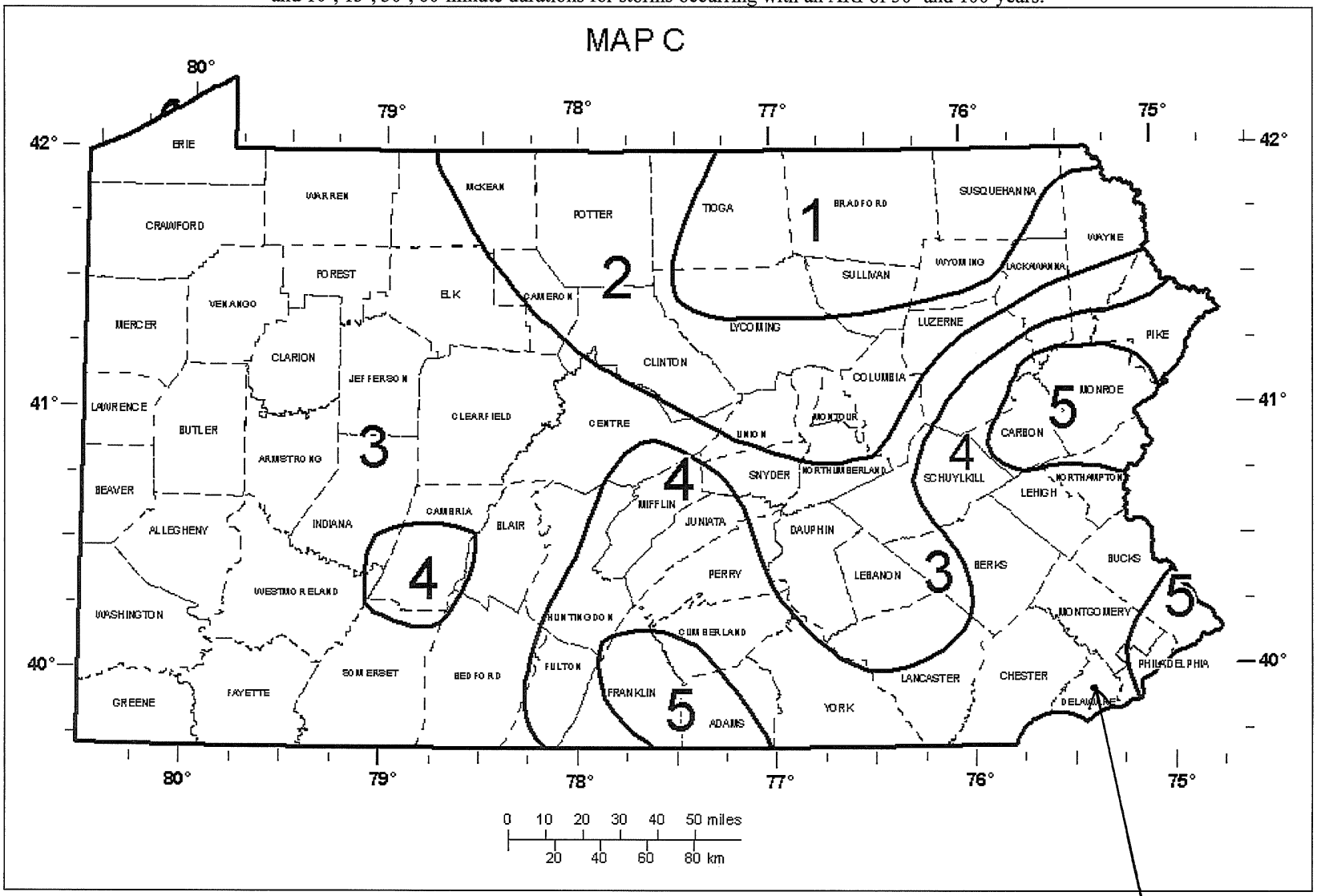


Figure 7A.3 Map C. 5- and 10-minute durations for storms occurring with an ARI of 1-, 2-, 5-, and 10-years, 10- and 15-minute durations for storms occurring with an ARI of 25-years and 10-, 15-, 30-, 60-minute durations for storms occurring with an ARI of 50- and 100-years.



Date 3/18/2011 Larson Design Group Computed By: MSK
Job No. 5887-002 Checked By: RDS
Sheet 1 of 1

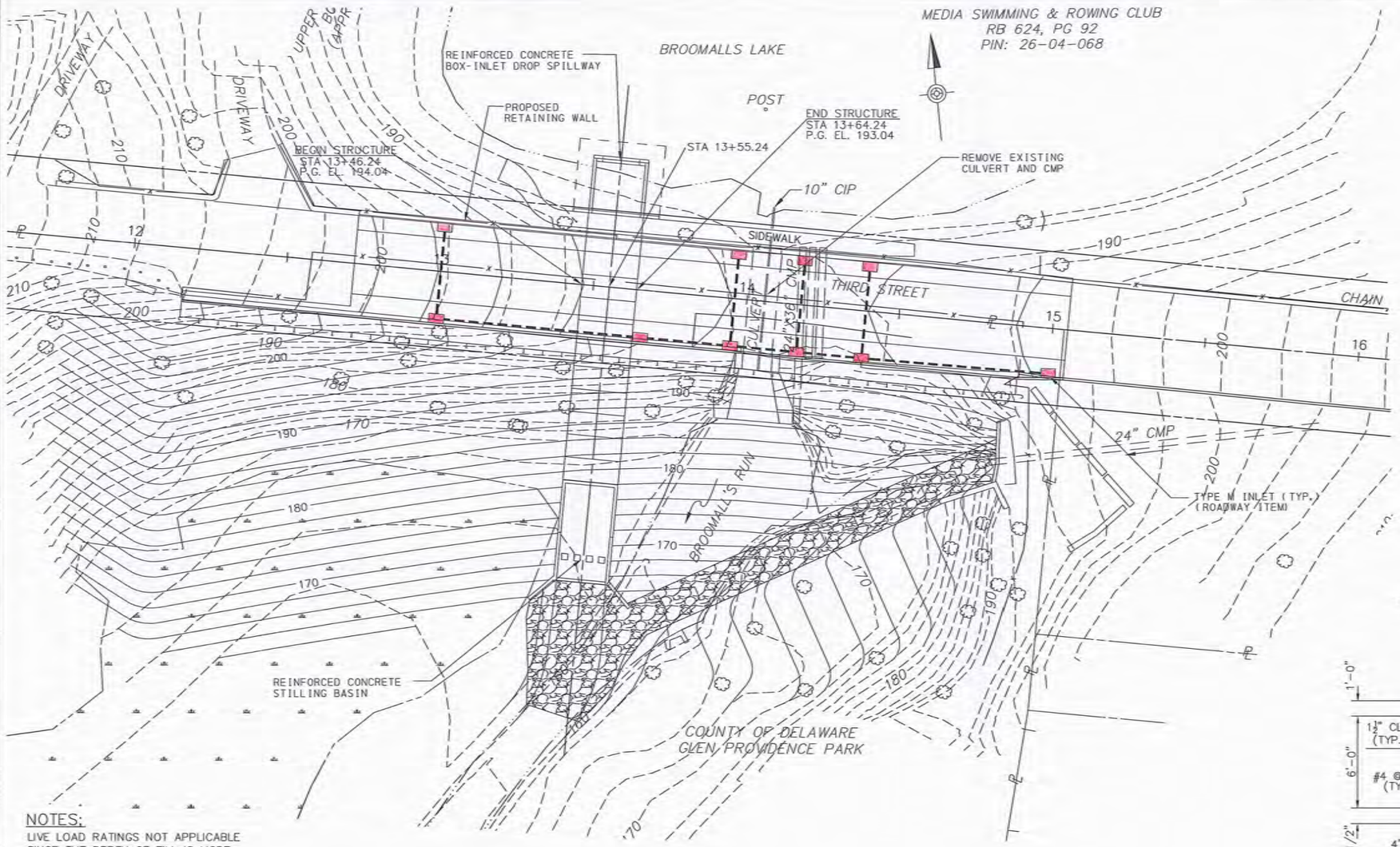
Job Name: 3rd Street Dam

Vertical Curve Input

PVI Sta	1394.54	r =	0.00088947			STA	ELEVATION	
PVI Elev.	188		Station	Elevation	Low Point	1417.59	191.7775148	
G1	-0.105	PVC	1299.54	197.98	(for sag curves only - Need to run LP Macro)			
G2	0.064	PVT	1489.54	194.08		STA	dy/dx	(Run Tangent Macro)
LC =	190					1500	0.0938	

Calculate Elevations

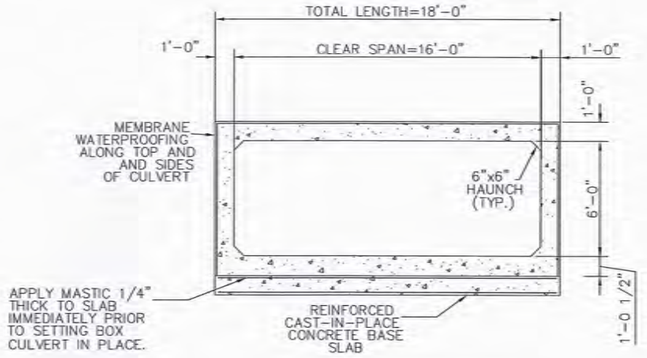
Description	Station	PG Elev		X	PG Elev	Out of Curve	Linear Interpolation	Difference
Culvert CL	1355.24	193.51	In Curve	55.70	193.5063	0		
LP	1417.59	191.78	In Curve	118.05	191.7775	0		
LP Far Flank	1438.99	191.98	In Curve	139.45	191.9812	0		
LP Near Flank	1395.99	191.98	In Curve	96.45	191.985	0	1083.590	
13+00.00	1300.00	197.93	In Curve	0.46	197.9268	0	1083.329	-885.402
Riser Box	1366.74	192.93	In Curve	67.20	192.9274	0	1083.068	-890.141
Begin Structure	1346.24	194.04	In Curve	46.70	194.0414	0	1082.807	-888.766
End Structure	1364.24	193.04	In Curve	64.70	193.0432	0	1082.546	-889.503
15+00.00	1500.00	194.75	After Curve	200.46	194.7981	194.7494	1082.285	-887.536
		334.43	Before Curve	-1299.54	1085.5	334.4267	1082.024	-747.597
		334.43	Before Curve	-1299.54	1085.5	334.4267	1081.763	-747.336
		334.43	Before Curve	-1299.54	1085.5	334.4267	1081.502	-747.075
		334.43	Before Curve	-1299.54	1085.5	334.4267	1081.241	-746.814
		334.43	Before Curve	-1299.54	1085.5	334.4267	1080.980	-746.553



PLAN

0 20

SCALE: 1"=20'



TYPICAL CULVERT SECTION

1/4" = 1'-0"

PRECAST BOX CULVERT SECTION

1/4" = 1'-0"

NOTES:

LIVE LOAD RATINGS NOT APPLICABLE SINCE THE DEPTH OF FILL IS MORE THAN 8.0' AND EXCEEDS THE SPAN LENGTH.

HYDRAULIC DATA:

DRAINAGE AREA= 0.55 SQ. MI.

DESIGN FLOOD:

FREQUENCY=25 YEAR
MAGNITUDE= 2200 CFS
PERT. W.S. ELEV.= 195.2

100 YEAR FLOOD RISK ASSESSMENT:

MAGNITUDE= 1362 CFS
VELOCITY= 9.6 FPS
PERT. W.S. ELEV.= 193.5

FLOOD OF RECORD= NONE

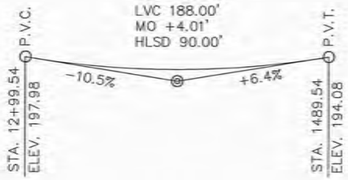
HORIZONTAL CURVE DATA:

CONST. ℄ THIRD STREET

NO HORIZONTAL CURVE

VERTICAL CURVE DATA:

CONST. ℄ THIRD STREET
PVI STA 13+94.54
ELEV 188.00
LVC 188.00'
MO +4.01'
HLSD 90.00'



SOIL BORING INFORMATION

BORING	STATION	OFFSET
B-1	5+60	44'-0" R
B-2	5+40	44'-0" R
B-3	5+50	12'-0" R
B-4	5+60	91'-0" L
B-5	5+39	91'-0" L
B-6	5+80	12'-0" R

DES: QDR | DWG: RDS | CKD: MSK

INDEX OF DRAWINGS	
SHEET	DESCRIPTION
1	GENERAL PLAN & BOX SECTION
2	GEN. NOTES AND SECTION
3	END SECTIONS AND DETAILS
4	WALL DETAILS
5	REINFORCEMENT BAR SCHEDULE

SURVEY PROVIDED BY:

STRUCTURAL CULVERT DESIGN PREPARED BY:

LARSON DESIGN GROUP
901 DAWN AVENUE
EPHRATA, PA. 17522
PHONE: 717-721-9008
FAX: 717-721-5643

BOROUGH OF MEDIA
DELAWARE COUNTY, PENNSYLVANIA

THIRD STREET DAM/ BRIDGE UPGRADE

STA 13+55.24

OVER BROOMALL'S RUN

PRECAST CONCRETE BOX CULVERT

GENERAL PLAN AND SECTION

SHEET 1 OF __

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Drainage Design

Inlet spacing - U/S side:

$$L = \frac{(43560)Q}{EIW} = \frac{(43560)(2)}{0.6(6.6)(16)} = 137.5 \qquad \text{(DM-2 Chap 10)}$$

- Locate inlet at low point of sag vertical curve, with flanking inlets at either side spaced 100 feet or at grade not greater than 0.20 ft above the sag inlet [DM-2 10.3.A.7.c]

- Inlet @ LP: 14+17.59
  - ℄ Roadway @ LP = 191.78
  - U/S Inlet EL = 191.78 - 11 x .02 - 5 x .04 = 191.36
  - D/S Inlet EL = 191.78 - 10 x .02 - 7 x .04 = 191.30
- Inlet @ 21.4' from LP on the Far side @ STA 14+38.99 → In Curve
  - ℄ Elevation @ 14+38.99 = 191.98 (From Vertical Curve Sheet)
  - U/S Inlet EL = 191.98 - 11 x .02 - 5 x .04 = 191.56
  - D/S Inlet EL = 191.98 - 10 x .02 - 7 x .04 = 191.50
- Inlet @ 21.6' from LP on the Near side @ STA 13+95.99 → In Curve
  - ℄ Elevation @ 13+95.99 = 191.98 (From Vertical Curve Sheet)
  - U/S Inlet EL 191.98 - 11 x .02 - 5 x .04 = 191.56
  - D/S Inlet EL 191.98 - 10 x .02 - 7 x .04 = 191.50
- Inlet @ 13+00 → Before Curve
  - ℄ Elevation @ 13+00 = 197.93 (From Vertical Curve Sheet)
  - U/S Inlet EL = 197.93 - 11 x .02 - 5 x .04 = 197.51
  - D/S Inlet EL = 197.93 - 10 x .02 - 7 x .04 = 197.45
- Inlet @ 15+00 D/S ONLY → After Curve
  - ℄ Elevation @ 15+00 = 194.75 (From Vertical Curve Sheet)
  - Inlet EL = 194.75 - 5 x .02 - 7 x .04 = 194.27

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Drainage Design (cont.)

- Inlets @ 13+00 U/S EL 197.54 D/S EL 197.45
  - U/S Inlet: 12" Top Slab & 1-6' riser box
    Pipe Invert: 190.51
  - D/S Inlet: 12" Top Slab & 1-7' riser box
    Pipe Invert: 189.45
  - Pipe Slope: (190.51 - 189.45) / 33 = 0.032

- Inlets @ 13+95.99 U/S EL 191.56 D/S EL 191.50
  - U/S Inlet: 12" Top Slab & 1-7' riser box
    Pipe Invert: 183.56
  - D/S Inlet: 12" Top Slab & 1-8' riser box
    Pipe Invert: 182.50
  - Pipe Slope: (183.56 - 182.50) / 33 = 0.032

- Inlets @ 14+38.99 U/S EL 191.56 D/S EL 191.50
  - U/S Inlet: 12" Top Slab & 1-6' riser box
    Pipe Invert: 184.56
  - D/S Inlet: 12" Top Slab & 1-7' riser box
    Pipe Invert: 183.50
  - Pipe Slope: (184.56 - 183.50) / 33 = 0.032

- Inlets @ 14+17.59 (Low Point) U/S EL 191.36 D/S EL 191.30
  - U/S Inlet: 12" Top Slab & 1-6' riser box
    Pipe Invert: 184.36
  - D/S Inlet: 12" Top Slab & 1-7' riser box
    Pipe Invert: 183.30
  - Pipe Slope: (184.36 - 183.30) / 33 = 0.032

Pipe Slope from 14+38.99 to 14+17.59 = (183.50 - 183.30) / 21.4 = 0.0093

Pipe Slope from 14+17.59 to 13+95.99 = (183.30 - 182.50) / 21.6 = 0.037

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Drainage Design (cont.)

- Riser Section adjacent to culvert
- Riser dimensions 48" x 48"
- ℄ Riser 13+55.24 + 8' + 1' + 6" + 2' = 13+66.74
- Outlet Invert of Riser at mid height of culvert:

  170+(62-16)x.005 = 170.23 + [3-(18/2)/12] = 172.48 → Mid Ht. of culvert @ roadway gutter

- Pipe from 13+95.99 outlet invert = 182.50

  Slope = (182.50 - 181.00) / 29.25 = 0.051

- Pipe from 13+00 outlet invert = 189.45

  Slope = (189.45 - 183.00) / 66.74 = 0.097

- Inlet @ 15+00 EL 194.27
  - D/S Inlet: 12" Top Slab & 1-6' riser

    Pipe Invert: 187.27

  Pipe Slope from 15+00 to 14+38.99 = (187.27 - 183.50) / 61.01 = 0.062

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Larson Design Group

JOB 5887-002 3rd Street Dam
SHEET NO. _____ OF _____
CALCULATED BY MSK DATE 3/15/11
CHECKED BY RDS DATE 3/18/11
SCALE _____

Additional Runoff due to D/S sidewalk

- New sidewalk will drain into gutter
- 5' wide sidewalk beginning at 12+17.00 to 14+90.00
- Runoff Factor and Rate of Rainfall are the same as on the drainage flow spreadsheet

• Inlet @ 13+00.00
Area = 5x' (13+00 - 10+17) = 415 ft²
Q = 0.6 x 6.6 x 415/43560 = 0.038 cfs

• Inlet @ 13+95.99
Area = 5x' (13+95.99 - 13+00) = 479.95 ft²
Q = 0.6 x 6.6 x 479.95/43560 = 0.044 cfs

• Inlet @ 14+38.99
Area = 5x (14+90 - 14+38.99) = 255.05 ft²
Q = 0.6 x 6.6 x 255.05/43560 = 0.023 cfs

• Inlet @ 14+17.59
Area = 5x [(14+38.99 - 14+17.59) + (14+17.59 - 13+95.99)] = 215 ft²
Q = 0.6 x 6.6 x 215/43560 = 0.020 cfs

Worksheet for Inlet: U/S LP 14+17.59

Project Description

Solve For	Spread

Input Data

Discharge		1.39	ft³/s
Gutter Width		5.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Grate Width		2.00	ft
Grate Length		3.77	ft
Local Depression		0.00	in
Local Depression Width		0.00	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Results

Spread	5.57	ft
Depth	0.21	ft
Gutter Depression	0.10	ft
Total Depression	0.10	ft
Open Grate Area	2.56	ft²
Active Grate Weir Length	7.77	ft

Worksheet for Inlet: D/S LP 14+17.59

Project Description

Solve For	Spread

Input Data

Discharge		1.25	ft³/s
Gutter Width		7.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Grate Width		2.00	ft
Grate Length		3.77	ft
Local Depression		0.00	in
Local Depression Width		0.00	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Results

Spread	5.02	ft
Depth	0.20	ft
Gutter Depression	0.14	ft
Total Depression	0.14	ft
Open Grate Area	2.56	ft²
Active Grate Weir Length	7.77	ft

Worksheet for Inlet: U/S 14+38.99

Project Description

Solve For	Efficiency

Input Data

Discharge		2.61	ft³/s
Slope		0.01900	ft/ft
Gutter Width		5.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Roughness Coefficient		0.028	
Grate Width		2.00	ft
Grate Length		3.77	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	77.28	%
Intercepted Flow	2.02	ft³/s
Bypass Flow	0.59	ft³/s
Spread	9.45	ft
Depth	0.29	ft
Flow Area	1.14	ft²
Gutter Depression	0.10	ft
Total Depression	0.10	ft
Velocity	2.29	ft/s
Splash Over Velocity	7.33	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.56	
Grate Flow Ratio	0.48	
Active Grate Length	3.77	ft

Worksheet for Inlet: D/S 14+38.99

Project Description

Solve For	Efficiency

Input Data

Discharge		4.13	ft³/s
Slope		0.01900	ft/ft
Gutter Width		7.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Roughness Coefficient		0.028	
Grate Width		2.00	ft
Grate Length		3.77	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	70.34	%
Intercepted Flow	2.91	ft³/s
Bypass Flow	1.23	ft³/s
Spread	10.35	ft
Depth	0.35	ft
Flow Area	1.56	ft²
Gutter Depression	0.14	ft
Total Depression	0.14	ft
Velocity	2.65	ft/s
Splash Over Velocity	7.33	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.49	
Grate Flow Ratio	0.41	
Active Grate Length	3.77	ft

Worksheet for Inlet: U/S 13+95.99

Project Description

Solve For	Efficiency

Input Data

Discharge		3.22	ft³/s
Slope		0.01900	ft/ft
Gutter Width		5.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Roughness Coefficient		0.028	
Grate Width		2.00	ft
Grate Length		3.77	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	75.00	%
Intercepted Flow	2.42	ft³/s
Bypass Flow	0.80	ft³/s
Spread	10.51	ft
Depth	0.31	ft
Flow Area	1.36	ft²
Gutter Depression	0.10	ft
Total Depression	0.10	ft
Velocity	2.38	ft/s
Splash Over Velocity	7.33	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.54	
Grate Flow Ratio	0.45	
Active Grate Length	3.77	ft

Worksheet for Inlet: D/S 13+95.99

Project Description

Solve For	Efficiency

Input Data

Discharge		0.13	ft³/s
Slope		0.01900	ft/ft
Gutter Width		7.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Roughness Coefficient		0.028	
Grate Width		2.00	ft
Grate Length		3.77	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	99.83	%
Intercepted Flow	0.13	ft³/s
Bypass Flow	0.00	ft³/s
Spread	2.42	ft
Depth	0.10	ft
Flow Area	0.12	ft²
Gutter Depression	0.14	ft
Total Depression	0.14	ft
Velocity	1.15	ft/s
Splash Over Velocity	7.33	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.81	
Grate Flow Ratio	0.99	
Active Grate Length	3.77	ft

Worksheet for Inlet: U/S 13+00.00

Project Description

Solve For	Efficiency

Input Data

Discharge		7.43	ft³/s
Slope		0.10000	ft/ft
Gutter Width		5.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Roughness Coefficient		0.028	
Grate Width		2.00	ft
Grate Length		3.77	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	56.71	%
Intercepted Flow	4.22	ft³/s
Bypass Flow	3.22	ft³/s
Spread	10.55	ft
Depth	0.31	ft
Flow Area	1.36	ft²
Gutter Depression	0.10	ft
Total Depression	0.10	ft
Velocity	5.46	ft/s
Splash Over Velocity	7.33	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.21	
Grate Flow Ratio	0.45	
Active Grate Length	3.77	ft

Worksheet for Inlet: D/S 13+00.00

Project Description

Solve For	Efficiency

Input Data

Discharge		1.25	ft³/s
Slope		0.10000	ft/ft
Gutter Width		7.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Roughness Coefficient		0.028	
Grate Width		2.00	ft
Grate Length		3.77	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	89.17	%
Intercepted Flow	1.11	ft³/s
Bypass Flow	0.13	ft³/s
Spread	4.07	ft
Depth	0.16	ft
Flow Area	0.33	ft²
Gutter Depression	0.14	ft
Total Depression	0.14	ft
Velocity	3.75	ft/s
Splash Over Velocity	7.33	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.34	
Grate Flow Ratio	0.84	
Active Grate Length	3.77	ft

Worksheet for Inlet: D/S 15+00.00

Project Description

Solve For	Efficiency

Input Data

Discharge		8.84	ft³/s
Slope		0.07380	ft/ft
Gutter Width		7.00	ft
Gutter Cross Slope		0.04	ft/ft
Road Cross Slope		0.02	ft/ft
Roughness Coefficient		0.028	
Grate Width		2.00	ft
Grate Length		3.77	ft
Grate Type	45˚ Tilt Bar		
Clogging		0.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	53.42	%
Intercepted Flow	4.72	ft³/s
Bypass Flow	4.12	ft³/s
Spread	10.86	ft
Depth	0.36	ft
Flow Area	1.67	ft²
Gutter Depression	0.14	ft
Total Depression	0.14	ft
Velocity	5.30	ft/s
Splash Over Velocity	7.33	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.22	
Grate Flow Ratio	0.40	
Active Grate Length	3.77	ft

Worksheet for 18" RCP @ 13+00.00

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	18.79	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.46	ft
Percent Full	100.0	%
Critical Slope	0.02827	ft/ft
Velocity	10.63	ft/s
Velocity Head	1.76	ft
Specific Energy	3.26	ft
Froude Number	0.00	
Maximum Discharge	20.21	ft^3/s
Discharge Full	18.79	ft^3/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP @ 13+00.00

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.46	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.02827	ft/ft

Worksheet for 18" CMP @ 13+00.00

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	10.18	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.23	ft
Percent Full	100.0	%
Critical Slope	0.03204	ft/ft
Velocity	5.76	ft/s
Velocity Head	0.52	ft
Specific Energy	2.02	ft
Froude Number	0.00	
Maximum Discharge	10.95	ft^3/s
Discharge Full	10.18	ft^3/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP @ 13+00.00

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.23	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.03204	ft/ft

Worksheet for 18" RCP @ 13+95.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	18.79	ft³/s
Flow Area	1.77	ft²
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.46	ft
Percent Full	100.0	%
Critical Slope	0.02827	ft/ft
Velocity	10.63	ft/s
Velocity Head	1.76	ft
Specific Energy	3.26	ft
Froude Number	0.00	
Maximum Discharge	20.21	ft³/s
Discharge Full	18.79	ft³/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP @ 13+95.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.46	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.02827	ft/ft

Worksheet for 18" CMP @ 13+95.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	10.18	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.23	ft
Percent Full	100.0	%
Critical Slope	0.03204	ft/ft
Velocity	5.76	ft/s
Velocity Head	0.52	ft
Specific Energy	2.02	ft
Froude Number	0.00	
Maximum Discharge	10.95	ft^3/s
Discharge Full	10.18	ft^3/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP @ 13+95.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.23	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.03204	ft/ft

Worksheet for 18" RCP @ 14+38.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	18.79	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.46	ft
Percent Full	100.0	%
Critical Slope	0.02827	ft/ft
Velocity	10.63	ft/s
Velocity Head	1.76	ft
Specific Energy	3.26	ft
Froude Number	0.00	
Maximum Discharge	20.21	ft^3/s
Discharge Full	18.79	ft^3/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP @ 14+38.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.46	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.02827	ft/ft

Worksheet for 18" CMP @ 14+38.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	10.18	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.23	ft
Percent Full	100.0	%
Critical Slope	0.03204	ft/ft
Velocity	5.76	ft/s
Velocity Head	0.52	ft
Specific Energy	2.02	ft
Froude Number	0.00	
Maximum Discharge	10.95	ft^3/s
Discharge Full	10.18	ft^3/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP @ 14+38.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.23	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.03204	ft/ft

Worksheet for 18" RCP @ LP 14+17.59

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	18.79	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.46	ft
Percent Full	100.0	%
Critical Slope	0.02827	ft/ft
Velocity	10.63	ft/s
Velocity Head	1.76	ft
Specific Energy	3.26	ft
Froude Number	0.00	
Maximum Discharge	20.21	ft^3/s
Discharge Full	18.79	ft^3/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP @ LP 14+17.59

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.46	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.02827	ft/ft

Worksheet for 18" CMP @ LP 14+17.59

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.03200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	10.18	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.23	ft
Percent Full	100.0	%
Critical Slope	0.03204	ft/ft
Velocity	5.76	ft/s
Velocity Head	0.52	ft
Specific Energy	2.02	ft
Froude Number	0.00	
Maximum Discharge	10.95	ft^3/s
Discharge Full	10.18	ft^3/s
Slope Full	0.03200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP @ LP 14+17.59

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.23	ft
Channel Slope	0.03200	ft/ft
Critical Slope	0.03204	ft/ft

Worksheet for 18" RCP from 14+38.99 to 14+17.59

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00930	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	10.13	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.23	ft
Percent Full	100.0	%
Critical Slope	0.00935	ft/ft
Velocity	5.73	ft/s
Velocity Head	0.51	ft
Specific Energy	2.01	ft
Froude Number	0.00	
Maximum Discharge	10.90	ft^3/s
Discharge Full	10.13	ft^3/s
Slope Full	0.00930	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP from 14+38.99 to 14+17.59

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.23	ft
Channel Slope	0.00930	ft/ft
Critical Slope	0.00935	ft/ft

Worksheet for 18" CMP from 14+38.99 to 14+17.59

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.00930	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	5.49	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	0.90	ft
Percent Full	100.0	%
Critical Slope	0.02038	ft/ft
Velocity	3.10	ft/s
Velocity Head	0.15	ft
Specific Energy	1.65	ft
Froude Number	0.00	
Maximum Discharge	5.90	ft^3/s
Discharge Full	5.49	ft^3/s
Slope Full	0.00930	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP from 14+38.99 to 14+17.59

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	0.90	ft
Channel Slope	0.00930	ft/ft
Critical Slope	0.02038	ft/ft

Worksheet for 18" RCP from 15+00.00 to 14+38.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.06200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	26.15	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.49	ft
Percent Full	100.0	%
Critical Slope	0.05768	ft/ft
Velocity	14.80	ft/s
Velocity Head	3.40	ft
Specific Energy	4.90	ft
Froude Number	0.00	
Maximum Discharge	28.13	ft^3/s
Discharge Full	26.15	ft^3/s
Slope Full	0.06200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP from 15+00.00 to 14+38.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.49	ft
Channel Slope	0.06200	ft/ft
Critical Slope	0.05768	ft/ft

Worksheet for 18" CMP from 15+00.00 to 14+38.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.06200	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	14.17	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.39	ft
Percent Full	100.0	%
Critical Slope	0.05373	ft/ft
Velocity	8.02	ft/s
Velocity Head	1.00	ft
Specific Energy	2.50	ft
Froude Number	0.00	
Maximum Discharge	15.24	ft^3/s
Discharge Full	14.17	ft^3/s
Slope Full	0.06200	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP from 15+00.00 to 14+38.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.39	ft
Channel Slope	0.06200	ft/ft
Critical Slope	0.05373	ft/ft

Worksheet for 18" RCP from 14+17.59 to 13+95.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.03700	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	20.20	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.47	ft
Percent Full	100.0	%
Critical Slope	0.03308	ft/ft
Velocity	11.43	ft/s
Velocity Head	2.03	ft
Specific Energy	3.53	ft
Froude Number	0.00	
Maximum Discharge	21.73	ft^3/s
Discharge Full	20.20	ft^3/s
Slope Full	0.03700	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP from 14+17.59 to 13+95.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.47	ft
Channel Slope	0.03700	ft/ft
Critical Slope	0.03308	ft/ft

Worksheet for 18" CMP from 14+17.59 to 13+95.99

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.03700	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	10.94	ft³/s
Flow Area	1.77	ft²
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.27	ft
Percent Full	100.0	%
Critical Slope	0.03516	ft/ft
Velocity	6.19	ft/s
Velocity Head	0.60	ft
Specific Energy	2.10	ft
Froude Number	0.00	
Maximum Discharge	11.77	ft³/s
Discharge Full	10.94	ft³/s
Slope Full	0.03700	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP from 14+17.59 to 13+95.99

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.27	ft
Channel Slope	0.03700	ft/ft
Critical Slope	0.03516	ft/ft

Worksheet for 18" RCP from 13+95.99 to Riser Box

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.05100	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	23.72	ft³/s
Flow Area	1.77	ft²
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.48	ft
Percent Full	100.0	%
Critical Slope	0.04679	ft/ft
Velocity	13.42	ft/s
Velocity Head	2.80	ft
Specific Energy	4.30	ft
Froude Number	0.00	
Maximum Discharge	25.52	ft³/s
Discharge Full	23.72	ft³/s
Slope Full	0.05100	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP from 13+95.99 to Riser Box

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.48	ft
Channel Slope	0.05100	ft/ft
Critical Slope	0.04679	ft/ft

Worksheet for 18" CMP from 13+95.99 to Riser Box

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.05100	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	12.85	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.35	ft
Percent Full	100.0	%
Critical Slope	0.04500	ft/ft
Velocity	7.27	ft/s
Velocity Head	0.82	ft
Specific Energy	2.32	ft
Froude Number	0.00	
Maximum Discharge	13.82	ft^3/s
Discharge Full	12.85	ft^3/s
Slope Full	0.05100	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP from 13+95.99 to Riser Box

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.35	ft
Channel Slope	0.05100	ft/ft
Critical Slope	0.04500	ft/ft

Worksheet for 18" RCP from 13+00.00 to Riser Box

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.09700	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	32.71	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.50	ft
Percent Full	100.0	%
Critical Slope	0.09255	ft/ft
Velocity	18.51	ft/s
Velocity Head	5.33	ft
Specific Energy	6.83	ft
Froude Number	0.00	
Maximum Discharge	35.19	ft^3/s
Discharge Full	32.71	ft^3/s
Slope Full	0.09700	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" RCP from 13+00.00 to Riser Box

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.50	ft
Channel Slope	0.09700	ft/ft
Critical Slope	0.09255	ft/ft

Worksheet for 18" CMP from 13+00.00 to Riser Box

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.024	
Channel Slope	0.09700	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft

Results

Discharge	17.72	ft^3/s
Flow Area	1.77	ft^2
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.45	ft
Percent Full	100.0	%
Critical Slope	0.08496	ft/ft
Velocity	10.03	ft/s
Velocity Head	1.56	ft
Specific Energy	3.06	ft
Froude Number	0.00	
Maximum Discharge	19.06	ft^3/s
Discharge Full	17.72	ft^3/s
Slope Full	0.09700	ft/ft
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
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for 18" CMP from 13+00.00 to Riser Box

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.45	ft
Channel Slope	0.09700	ft/ft
Critical Slope	0.08496	ft/ft

Appendix B

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