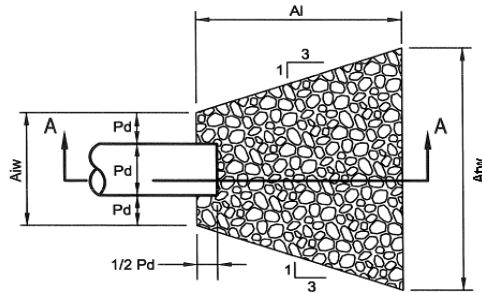
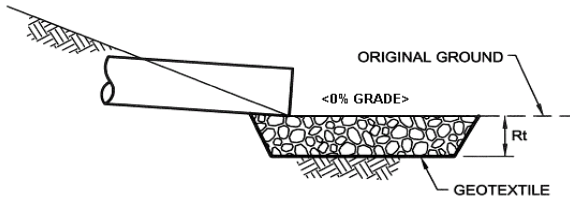


RIPRAP APRON OUTLET PROTECTION (STANDARD CONSTRUCTION DETAIL #9-2)



PLAN VIEW



SECTION A - A

NO.	PIPE DIA. Do (in)	TAIL WATER COND. (Max or Min)	MAN. "n" FOR PIPE	PIPE SLOPE (FT/FT)	Q (CFS)	V* (FPS)	RIPRAP SIZE	Rt (in)	Al (ft)	Aiw (ft)	Atw (ft)
EW 1	18	Min	0.013	0.013	6.60	5.53	R-4	18	8	4.50	12.50

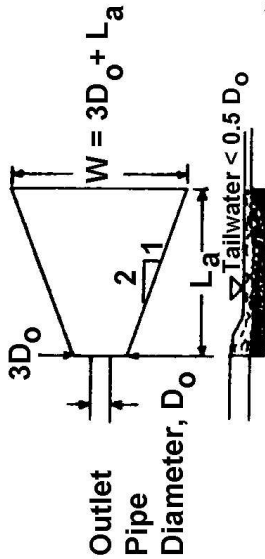
*The anticipated velocity (V) should not exceed the maximum permissible shown in Table 6.6 for the proposed riprap protection. Adjust for less than full pipe flow. Use Manning's equation to calculate velocity for pipe slopes ≥ 0.05 ft/ft.

Link Summary

SN Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Diameter or Height (in)	Manning's Roughness	Peak Flow (cfs)	Design Flow Capacity (cfs)	Peak Flow/Design Flow Ratio	Peak Flow Velocity (ft/sec)	Peak Flow Depth (ft)	Peak Flow Depth/Total Depth Ratio	Total Time Reported (min)	Surcharged Condition
1	Link-01	Pipe	EX MH 818-12	EX MH 818-1599	409.54	832.65	787.85	10.9400	10.000	0.0150	6.61	6.28	1.05	12.34	0.80	0.96	0.00 > CAPACITY
2	Link-02	Pipe	Jun-09	Jun-07	16.00	834.19	834.10	0.5600	10.000	0.0150	1.35	1.42	0.95	2.62	0.83	1.00	7.00 SURCHARGED
3	Link-03	Pipe	Jun-08	Jun-07	14.25	835.16	834.17	6.9500	10.000	0.0150	1.03	5.01	0.21	5.48	0.83	1.00	6.00 SURCHARGED
4	Link-04	Pipe	Jun-07	MH818-11	250.00	833.97	832.90	0.4300	10.000	0.0150	1.73	1.24	1.40	3.18	0.83	1.00	7.00 SURCHARGED
5	Link-05	Pipe	Inlet818-16	MH818-11	12.00	835.25	833.00	18.7500	12.000	0.0150	0.63	13.37	0.05	5.20	0.96	0.96	0.00 Calculated
6	Link-06	Pipe	Inlet818-15	MH818-11	14.00	835.57	832.90	19.0700	12.000	0.0120	2.88	16.86	0.17	8.49	0.92	0.92	0.00 Calculated
7	Link-07	Pipe	MH818-11	EX MH 818-12	23.25	832.88	832.75	0.5600	10.000	0.0150	4.71	1.42	3.32	8.68	0.82	0.98	0.00 > CAPACITY
8	Link-08	Pipe	Inlet818-14	EX MH 818-12	11.00	836.01	832.80	29.1800	12.000	0.0120	0.05	20.85	0.00	3.45	0.33	0.33	0.00 Calculated
9	Link-09	Pipe	Inlet818-13	EX MH 818-12	16.75	835.63	833.55	12.4200	12.000	0.0120	2.06	13.60	0.15	10.07	0.31	0.31	0.00 Calculated
10	Pipe - (3)	Pipe	EX MH 818-1599	STM MH 1	69.00	787.85	787.15	1.0100	18.000	0.0120	6.60	11.46	0.58	4.70	1.11	0.74	0.00 Calculated
11	Pipe - (4)	Pipe	STM MH 1	Out-1Pipe - (4)	4.00	787.15	787.10	1.2500	18.000	0.0120	6.60	12.72	0.52	5.53	0.96	0.64	0.00 Calculated
12	Link-14	Channel	Inlet818-13	Out-01	460.00	835.63	787.00	10.5700	3.000	0.0160	0.86	80.58	0.01	2.15	0.02	0.08	0.00
13	Link-16	Channel	Inlet818-14	Inlet818-16	24.46	838.31	837.90	1.6800	3.000	0.0160	0.07	31.21	0.00	0.29	0.01	0.05	0.00
14	Link-17	Channel	Inlet818-15	Inlet818-13	20.87	838.42	838.41	0.0500	3.000	0.0160	2.39	10.78	0.22	1.52	0.07	0.27	0.00
15	Link-18	Channel	Inlet818-16	Out-03	459.87	835.25	787.00	10.4900	3.000	0.0160	1.74	169.66	0.01	2.37	0.02	0.07	0.00
16	Link-19	Channel	Jun-08	Jun-09	24.58	837.41	837.34	0.2800	3.000	0.0160	8.17	9.67	0.84	2.71	0.15	0.63	0.00
17	Link-20	Channel	Jun-09	Out-04	70.18	834.19	830.00	5.9700	6.000	0.0300	8.41	148.10	0.06	3.23	0.09	0.18	0.00

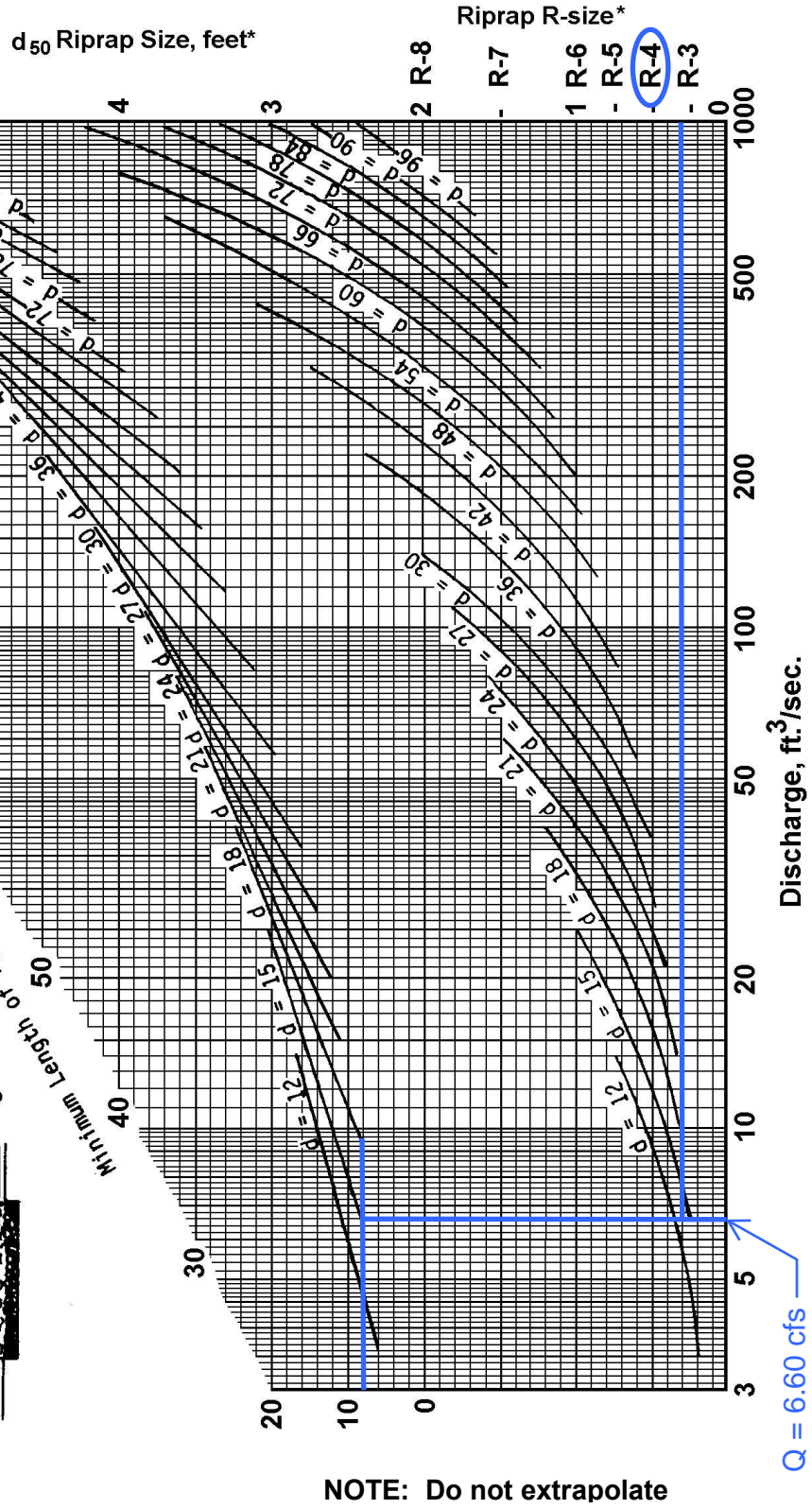
FIGURE 9.3 Riprap Apron Design, Minimum Tailwater Condition

DESIGN OF RIPRAP APRON OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL MINIMUM TAILWATER CONDITION ($T_w < 0.5$ DIAMETER)



Adapted from USDA - NRCS

Not to be used for Box Culverts



NOTE: Do not extrapolate

$L_a = 8'$
 $W = 3(1.50) + 8$
 $W = 12.50'$

* For discharge velocities exceeding Maximum Allowable for Riprap indicated, increase d_{50} stone size and/or provide velocity reduction device.

TABLE 6.6
Riprap Gradation, Filter Blanket Requirements, Maximum Velocities

Percent Passing (Square Openings)						
Class, Size NO.	R-8	R-7	R-6	R-5	R-4	R-3
Rock Size (Inches)						
42	100					
30		100				
24	15-50		100			
18		15-50		100		
15	0-15					
12		0-15	15-50		100	
9				15-50		
6			0-15		15-50	100
4				0-15		
3					0-15	15-50
2						0-15
Nominal Placement Thickness (inches)	63	45	36	27	18	9
Filter Stone¹	AASHTO #1	AASHTO #1	AASHTO #1	AASHTO #3	AASHTO #3	AASHTO #57
V_{max} (ft/sec)	17.0	14.5	13.0	11.5	9.0	6.5

Adapted from PennDOT Pub. 408, Section 703.2(c), Table C

- 1 This is a general standard. Soil conditions at each site should be analyzed to determine actual filter size. A suitable woven or non-woven geotextile underlayment, used according to the manufacturer's recommendations, may be substituted for the filter stone for gradients < 10%.

TABLE 6.7
Comparison of Various Gradations of Coarse Aggregates

AASHTO NUMBER	Total Percent Passing														
	6 ½"	4"	3 ½"	2 ½"	2"	1 ½"	1"	¾"	½"	⅜"	#4	#8	#16	#30	#100
1		100	90-100	25-60		0-15		0-5							
3				100	90-100	35-70	0-15		0-5						
5						100	90-100	20-55	0-10	0-5					
57						100	90-100		25-60		0-10	0-5			
67							100	90-100		20-55	0-10	0-5			
7								100	90-100	40-70	0-15	0-5			
8									100	85-100	10-30	0-10	0-5		
10										100	75-100				10-30

PennDOT Publication 408, Section 703.2(c), Table C

Tables 6.6 and 6.7 should be placed on the plan drawings of all sites where riprap channel linings are proposed.