WVENG-93 WV ENG-WS- 430 or 516 Conveyance Pipeline Friction Loss Work Sheet

Operator		Designed By		Date:
Farm Name		Checked By		Date:
Service Center		Approved By		Date:
County				

The irrigation line will be evaluated for the optimum size and pipeline material selected according to the maximum pressure rating anticipated for the pipeline. If the pressure tank is not at the pump, remember to separate the system into a minimum of two systems, one system line to the pressure tank and one system line leaving the the pressure tank. Document the head loss on the system (dynamic and static) does not exceed the working pressure of the pipeline (72% of the rated pipeline pressure). The final pipeline material and diameter will be chosen in conjuction with the pump selection and associated pumping curve .

Well Water Depth (FT)	Pressure Tank		Irrigation Emitter Pressure	Filter Losses	Other Losses
	Min. PSI	Max. PSI	PSI	PSI	PSI

Define Pipeline, Material, Diameter, Design Q (GPM)- Refer to the Plan Layout, WV ENG 430 Pipeline Friction Losses

Field	Pipe Name: Main, Submain, Header, Lateral	Design Capacity (GPM)	Type of Pipe PVC, PE, etc.	Type of material (PIP, SDR, IPS)	Pipe Size	Pipeline Working Pressure (PSI)	a) Length	Fitting Type	b) Fittings Equivelent Length	c) Total Length /100' (a+b)	d) Pipe Friction Loss (PSI)/100'	e) Pipe Friction Loss = c x d (PSI)	f) Pipe Friction Loss = (ft) e/2.31	g) Elevation Difference (-downhill), + uphill) (ft)	h) Total Head Loss (f+g) (ft)

Other Losses	**PSI**			
Irrigation Emitter Pressure (PSI)				
Filter Losses (PSI)				
Trough Valve (PSI)				
Water Pressure Tank (Maximum PSI)				
Other (PSI)				
Total Losses (FT) Sum g				
Total Losses (PSI) = Ft/2.31				
Is the Working Pressure of Selected Pipe PSI > Total Losses?				

The following tables provide specific information about different types of pipelines used as livestock watering pipelines or irrigation pipelines. Information such as velocity, estimated friction losses reported in PSI per 100 feet of pipe or Ft/ per 100 feet of pipe, and the associated C factor. These friction loss tables can be used in lieu of calculating the Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft). hf = 10.536 x ((Q^ 1.852)/(C^1.852)) x (D^-4.871) x L(ft)

Table	Pipe Material
1a.	HDPE SIDR PR Controlled; manufactured under ASTM D3035 and ASTM 3350 , Most common used for underground or surface lines
1b.	PE Low Linear Density - used mainly for header pipe on low pressure microirrigation systems
1c.	PVC Layflat hose, higher working pressure, above ground used as mainlines from pump, above ground only, not typuically cost shared.
2	Linear Low Density PE Oval Blue Strip Blank Tubing , typical Irrigation Blue Strip Pipe, used for headers or submain.
3	PVC Flexible Layflat Hoses, above ground header lines, low pressure
4	SCH 40 PVC Non-Threaded Rated Plastic Pipe Friction Loss Characteristics for ASTM D1785 materials
5	PVC SDR 17 Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120;
6	PVC SDR 21 Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120
7	PVC SDR 26 Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120
8	PVC SDR 32.5 Rated Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials
9	Polybutylene Water Service Pipe IPS- ID ASTM D2662, SDR 11.5; 160 PSI at 73.48 Deg. F.
10	Polybutylene Water Service Pipe CPS- ID ASTM D2662, SDR 9 250 PSI at 73.4 Deg. F
11	Thrust Block Design; Table 11
11a	Thrust Block Blank Design; Table 11
12	Pipe Pressure Rating Tables
13	Pipe Fittings and C Factors
14	Travel Gun Friction Factors for Tow Line
15	Surge Pressure Computations
16a	Example Pipe Friction, Elevation and Pressure Flow Computations
16b	Pipeline Design Blank Worksheet

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PIPELINE FRICTION LOSS TABLES: Table 1a

HDPE SIDR PR Controlled; manufactured under ASTM D3035 and ASTM 3350 , Material is HD PE 3608/ 3408; Most common used for underground or surface lines; Allowable pipe pressure design 72% of rated PSI at 43.48 F; Hazen Williams C (Part 623 Irrigation, Chapter 7, Table 7-23) 1 PSI= 2.31 ft.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

C=		130			130			130			140			140			140			140			150			150	
SIZE "		1/2			3/4"			1"			1 1/4"			1 1/2			2			2 1/2			3			4	
ID		0.622			0.824			1.049			1.38			1.61			2.067			2.469			3.068			4.026	
Area ID- SF		0.002			0.004			0.006			0.010			0.014			0.023			0.033			0.051			0.088	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/ 100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/ 100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/ 100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/ 100'
1	1.09	0.56	1.29	0.62	0.14	0.33	0.38	0.04	0.10	0.22	0.01	0.02	0.16	0.00	0.01	0.10	0.00	0.00	0.07	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00
2	2.18	2.02	4.67	1.24	0.51	1.19	0.77	0.16	0.37	0.44	0.04	0.08	0.33	0.02	0.04	0.20	0.01	0.01	0.14	0.00	0.00	0.09	0.00	0.00	0.05	0.00	0.00
3	3.27	4.28	9.90	1.86	1.09	2.52	1.15	0.34	0.78	0.66	0.08	0.18	0.49	0.04	0.08	0.30	0.01	0.02	0.21	0.00	0.01	0.13	0.00	0.00	0.08	0.00	0.00
4	4.36	7.30	16.86	2.48	1.86	4.29	1.53	0.57	1.32	0.89	0.13	0.30	0.65	0.06	0.14	0.39	0.02	0.04	0.28	0.01	0.02	0.18	0.00	0.01	0.10	0.00	0.00
5	Greater than 5 FPS			3.11	2.81	6.48	1.92	0.87	2.00	1.11	0.20	0.46	0.81	0.09	0.22	0.49	0.03	0.06	0.35	0.01	0.03	0.22	0.00	0.01	0.13	0.00	0.00
6				3.73	3.93	9.08	2.30	1.21	2.80	1.33	0.28	0.64	0.98	0.13	0.30	0.59	0.04	0.09	0.42	0.02	0.04	0.27	0.01	0.01	0.16	0.00	0.00
7				4.35	5.23	12.08	2.68	1.61	3.73	1.55	0.37	0.85	1.14	0.17	0.40	0.69	0.05	0.12	0.48	0.02	0.05	0.31	0.01	0.02	0.18	0.00	0.00
8				4.97	6.70	15.47	3.07	2.07	4.78	1.77	0.47	1.09	1.30	0.22	0.52	0.79	0.07	0.15	0.55	0.03	0.06	0.36	0.01	0.02	0.21	0.00	0.01
9				Greater than 5 FPS			3.45	2.57	5.94	1.99	0.59	1.36	1.46	0.28	0.64	0.89	0.08	0.19	0.62	0.03	0.08	0.40	0.01	0.02	0.23	0.00	0.01
10		PE Materials and Pressure Rating					3.83	3.13	7.22	2.21	0.72	1.66	1.63	0.34	0.78	0.99	0.10	0.23	0.69	0.04	0.10	0.45	0.01	0.03	0.26	0.00	0.01
12	Pipe Size						4.60	4.38	10.12	2.66	1.00	2.32	1.95	0.47	1.10	1.18	0.14	0.32	0.83	0.06	0.14	0.54	0.02	0.04	0.31	0.00	0.01
14	Typ.	Material	SIDR	PR (PSI)	Alow PR		Greater than 5 FPS			3.10	1.34	3.09	2.28	0.63	1.46	1.38	0.19	0.43	0.97	0.08	0.18	0.63	0.02	0.06	0.36	0.01	0.01
16	3/4"- 2.0"	3408	15	100	72					3.54	1.71	3.95	2.60	0.81	1.87	1.58	0.24	0.55	1.11	0.10	0.23	0.72	0.03	0.07	0.42	0.01	0.02
18	3/4"- 2.0"	3306 & 3406	15	80	58					3.99	2.13	4.92	2.93	1.00	2.32	1.78	0.30	0.69	1.25	0.13	0.29	0.81	0.04	0.09	0.47	0.01	0.02
20	1/2"-2.0"	3408	11.5	125	90					4.43	2.59	5.98	3.25	1.22	2.82	1.97	0.36	0.84	1.38	0.15	0.35	0.90	0.05	0.11	0.52	0.01	0.03
22	1/2"-2.0"	3306 & 3406	11.5	100	72					4.87	3.09	7.13	3.58	1.46	3.36	2.17	0.43	1.00	1.52	0.18	0.42	0.99	0.06	0.13	0.57	0.01	0.03
24	3/4"- 2.0"	3408	9	160	115					Greater than 5 FPS			3.90	1.71	3.95	2.37	0.51	1.17	1.66	0.21	0.49	1.08	0.07	0.15	0.62	0.02	0.04
26	3/4"- 2.0"	3306 & 3406	9	125	90								4.23	1.98	4.58	2.57	0.59	1.36	1.80	0.25	0.57	1.16	0.08	0.17	0.68	0.02	0.05
28	3/4"- 2.0"	3408	7	200	144								4.56	2.28	5.26	2.76	0.67	1.56	1.94	0.28	0.66	1.25	0.09	0.20	0.73	0.02	0.05
30	3/4"- 2.0"	3306 & 3406	7	160	115								4.88	2.59	5.98	2.96	0.77	1.77	2.08	0.32	0.74	1.34	0.10	0.23	0.78	0.03	0.06
35	3/4"- 2.0"	3408	5.3	250	180								Greater than 5 FPS			3.45	1.02	2.35	2.42	0.43	0.99	1.57	0.13	0.30	0.91	0.03	0.08
40	3/4"- 2.0"	3306 & 3406	5.3	200	144											3.95	1.31	3.02	2.77	0.55	1.27	1.79	0.17	0.39	1.04	0.04	0.10
45																4.44	1.62	3.75	3.11	0.68	1.58	2.02	0.21	0.48	1.17	0.06	0.13
50																4.94	1.97	4.56	3.46	0.83	1.92	2.24	0.25	0.59	1.30	0.07	0.16
55																Greater than 5 FPS			3.80	0.99	2.29	2.46	0.30	0.70	1.43	0.08	0.19
60																			4.15	1.16	2.69	2.69	0.36	0.82	1.56	0.09	0.22
65																			4.50	1.35	3.12	2.91	0.41	0.95	1.69	0.11	0.25
70																			4.84	1.55	3.58	3.14	0.47	1.09	1.82	0.13	0.29
75																			Greater than 5 FPS			3.36	0.54	1.24	1.95	0.14	0.33
80																						3.58	0.61	1.40	2.08	0.16	0.37
85																						3.81	0.68	1.57	2.21	0.18	0.42
90																						4.03	0.75	1.74	2.34	0.20	0.46
95																						4.26	0.83	1.92	2.47	0.22	0.51
100																						4.48	0.92	2.12	2.60	0.24	0.56
110																						4.93	1.09	2.52	2.86	0.29	0.67
120																						Greater than 5 FPS			3.12	0.34	0.79
130																									3.38	0.40	0.92
140																									3.64	0.45	1.05
150																									3.90	0.52	1.19
160																									4.16	0.58	1.35
170																									4.42	0.65	1.51
180																									4.68	0.72	1.67
190																									4.94	0.80	1.85
200																									Greater than 5 FPS		

PIPELINE FRICTION LOSS TABLES: Table 1b

Linear Low Density PE Oval Blue Strip Blank Tubing , typical Irrigation Blue Strip Pipe, used for headers or submain. Polyethylene (PE) SIDR Pressure Rated Pipe Friction Loss Characteristics for ASTM D2239 materials; Allowable pipe pressure design 72% of rated PSI at 43.48 F ; 1 PSI= 2.31 Ft
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM),Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

	42 PSI PE Blue Strip Pipe Typical Sizes 1/2", 5/8", 3/4", 1"												21 PSI Oval Hose Flatube (not drive over) -for low pressure systems								
C=		130			130			130			130			140			140			150	
SIZE "		1/2			5/8			3/4			1			1 1/2			2			4	
ID		0.503			0.633			0.813			1.043			1.595			2.052			4.026	
Area ID- SF		0.001			0.002			0.004			0.006			0.014			0.023			0.088	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/ 100'	Velocity FPS	PSI LOSS/ 100'	FT. LOSS/ 100'	Velocity FPS	PSI LOSS/ 100'	FT. LOSS/ 100'	Velocity FPS	PSI LOSS/1 00'	FT. LOSS/1 00'	Velocity FPS	PSI LOSS/100'	FT. LOSS/1 00'	Velocity FPS	PSI LOSS/ 100'	FT. LOSS/1 00'	Velocity FPS	PSI LOSS/ 100'	FT. LOSS/10 0'
1	1.67	1.58	3.64	1.05	0.51	1.19	0.64	0.15	0.35	0.39	0.05	0.10	0.17	0.00	0.01	0.10	0.00	0.00	0.03	0.00	0.00
2	3.33	5.69	13.14	2.10	1.86	4.29	1.28	0.55	1.27	0.78	0.16	0.38	0.33	0.02	0.04	0.20	0.01	0.01	0.05	0.00	0.00
3	5.00	12.05	27.84	3.16	3.93	9.09	1.91	1.16	2.69	1.16	0.35	0.80	0.50	0.04	0.09	0.30	0.01	0.03	0.08	0.00	0.00
4	Greater than 5 FPS			4.21	6.70	15.48	2.55	1.98	4.58	1.55	0.59	1.36	0.66	0.06	0.15	0.40	0.02	0.04	0.10	0.00	0.00
5				Greater than 5 FPS			3.19	2.99	6.92	1.94	0.89	2.06	0.83	0.10	0.23	0.50	0.03	0.07	0.13	0.00	0.00
6							3.83	4.20	9.70	2.33	1.25	2.88	0.99	0.14	0.32	0.60	0.04	0.09	0.16	0.00	0.00
7							4.47	5.58	12.90	2.71	1.66	3.83	1.16	0.18	0.42	0.70	0.05	0.12	0.18	0.00	0.00
8							Greater than 5 FPS			3.10	2.13	4.91	1.33	0.23	0.54	0.80	0.07	0.16	0.21	0.00	0.01
9										3.49	2.64	6.11	1.49	0.29	0.67	0.90	0.09	0.20	0.23	0.00	0.01
10										3.88	3.21	7.42	1.66	0.35	0.82	1.00	0.10	0.24	0.26	0.00	0.01
12										4.65	4.50	10.41	1.99	0.50	1.15	1.20	0.15	0.34	0.31	0.00	0.01
14										Greater than 5 FPS			2.32	0.66	1.52	1.40	0.19	0.45	0.36	0.01	0.01
16													2.65	0.85	1.95	1.60	0.25	0.57	0.42	0.01	0.02
18													2.98	1.05	2.43	1.80	0.31	0.71	0.47	0.01	0.02
20													3.32	1.28	2.95	2.00	0.37	0.87	0.52	0.01	0.03
22													3.65	1.52	3.52	2.20	0.45	1.03	0.57	0.01	0.03
24													3.98	1.79	4.14	2.40	0.53	1.21	0.62	0.02	0.04
26													4.31	2.08	4.80	2.60	0.61	1.41	0.68	0.02	0.05
28	21 PSI PE Blue Strip Pipe Typical Sizes 1/2", 1", 1 1/4", 1 1 1/2", 2", 2", 3", 4"												4.64	2.38	5.50	2.80	0.70	1.61	0.73	0.02	0.05
30	42 PSI PE Blue Strip Pipe Typical Sizes 1/2", 5/8", 3/4", 1", 1 1/4", 1 1 1/2", 2"												4.97	2.71	6.26	3.00	0.79	1.83	0.78	0.03	0.06
35													Greater than 5 FPS			3.51	1.06	2.44	0.91	0.03	0.08
40																4.01	1.35	3.12	1.04	0.04	0.10
45																4.51	1.68	3.89	1.17	0.06	0.13
50																Greater than 5 FPS			1.30	0.07	0.16
55																			1.43	0.08	0.19
60																			1.56	0.09	0.22
65																			1.69	0.11	0.25
70																			1.82	0.13	0.29
75																			1.95	0.14	0.33
80																			2.08	0.16	0.37
85																			2.21	0.18	0.42
90																			2.34	0.20	0.46
95																			2.47	0.22	0.51
100																			2.60	0.24	0.56
110																			2.86	0.29	0.67
120																			3.12	0.34	0.79
130																			3.38	0.40	0.92
140																			3.64	0.45	1.05
150																			3.90	0.52	1.19
160																			4.16	0.58	1.35
170																			4.42	0.65	1.51
180																			4.68	0.72	1.67
190																			4.94	0.80	1.85

200	Greater than 5 FPS

PIPELINE FRICTION LOSS TABLES: Table 1c

Layflat Vinylflow Hose, high tensile ; Allowable pipe pressure design 72% of rated PSI at 43.48 F ; Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 14), D= ID of pipe (inches), L=100 (ft).

C=		120			130			140			140			140	
SIZE "		1 1/2			2			3			4			5	
ID		1.506			2.106			3.09			4.094			5.079	
Area ID- SF		0.012			0.024			0.052			0.091			0.141	
Working Pressure		80			80			70			70			60	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	0.19	0.01	0.02	0.10	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00
2	0.37	0.03	0.07	0.19	0.01	0.01	0.09	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00
3	0.56	0.07	0.15	0.29	0.01	0.03	0.13	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00
4	0.74	0.11	0.26	0.38	0.02	0.04	0.18	0.00	0.01	0.10	0.00	0.00	0.07	0.00	0.00
5	0.93	0.17	0.40	0.48	0.03	0.07	0.22	0.00	0.01	0.13	0.00	0.00	0.08	0.00	0.00
6	1.12	0.24	0.56	0.57	0.04	0.09	0.27	0.01	0.01	0.15	0.00	0.00	0.10	0.00	0.00
7	1.30	0.32	0.74	0.67	0.05	0.13	0.31	0.01	0.02	0.18	0.00	0.00	0.11	0.00	0.00
8	1.49	0.41	0.95	0.76	0.07	0.16	0.35	0.01	0.02	0.20	0.00	0.01	0.13	0.00	0.00
9	1.67	0.51	1.18	0.86	0.09	0.20	0.40	0.01	0.03	0.23	0.00	0.01	0.15	0.00	0.00
10	1.86	0.62	1.44	0.95	0.10	0.24	0.44	0.01	0.03	0.25	0.00	0.01	0.16	0.00	0.00
12	2.23	0.87	2.02	1.14	0.15	0.34	0.53	0.02	0.05	0.30	0.01	0.01	0.20	0.00	0.00
14	2.60	1.16	2.68	1.33	0.20	0.45	0.62	0.03	0.06	0.35	0.01	0.02	0.23	0.00	0.01
16	2.97	1.49	3.44	1.52	0.25	0.58	0.71	0.03	0.08	0.40	0.01	0.02	0.26	0.00	0.01
18	3.35	1.85	4.27	1.71	0.31	0.72	0.80	0.04	0.10	0.45	0.01	0.02	0.29	0.00	0.01
20	3.72	2.25	5.19	1.90	0.38	0.87	0.88	0.05	0.12	0.50	0.01	0.03	0.33	0.00	0.01
25	4.65	3.40	7.85	2.38	0.57	1.32	1.10	0.08	0.18	0.63	0.02	0.05	0.41	0.01	0.02
30	Greater than 5 FPS			2.85	0.80	1.85	1.33	0.11	0.25	0.75	0.03	0.06	0.49	0.01	0.02
35				3.33	1.07	2.47	1.55	0.14	0.33	0.88	0.04	0.08	0.57	0.01	0.03
40				3.80	1.37	3.16	1.77	0.18	0.43	1.01	0.05	0.11	0.65	0.02	0.04
45				4.28	1.70	3.93	1.99	0.23	0.53	1.13	0.06	0.13	0.74	0.02	0.05
50				4.75	2.07	4.77	2.21	0.28	0.64	1.26	0.07	0.16	0.82	0.02	0.06
55				Greater than 5 FPS			2.43	0.33	0.77	1.38	0.08	0.20	0.90	0.03	0.07
60							2.65	0.39	0.90	1.51	0.10	0.23	0.98	0.03	0.08
65							2.87	0.45	1.05	1.64	0.12	0.27	1.06	0.04	0.09
70							3.09	0.52	1.20	1.76	0.13	0.30	1.14	0.05	0.11
75							3.31	0.59	1.36	1.89	0.15	0.35	1.23	0.05	0.12
80							3.53	0.67	1.54	2.01	0.17	0.39	1.31	0.06	0.14
85							3.75	0.74	1.72	2.14	0.19	0.44	1.39	0.07	0.15
90							3.98	0.83	1.91	2.26	0.21	0.49	1.47	0.07	0.17
95							4.20	0.91	2.11	2.39	0.23	0.54	1.55	0.08	0.19
100							4.42	1.01	2.32	2.52	0.26	0.59	1.63	0.09	0.21
120							Greater than 5 FPS			3.02	0.36	0.83	1.96	0.13	0.29
140										3.52	0.48	1.10	2.29	0.17	0.39
160										4.03	0.61	1.41	2.62	0.21	0.49
180										4.53	0.76	1.75	2.94	0.27	0.61
200										Greater than 5 FPS			3.27	0.32	0.75
220													3.60	0.39	0.89
240													3.92	0.45	1.04
260													4.25	0.52	1.21
280													4.58	0.60	1.39
300													4.90	0.68	1.58

FRICTION LOSS TABLES: Table 2

SCH 40 PVC Non-Threaded Rated Plastic Pipe Friction Loss Characteristics for ASTM D1785 materials; Allowable pipe pressure design 72% of rated PSI at 43.48 F varies.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

C=		130			130			130			140			140			140			140			150			150			150	
SIZE "		1/2			3/4			1			1 1/4			1 1/2			2			2 1/2			3			4			6	
OD		0.84			1.05			1.315			1.66			1.9			2.375			2.875			3.5			4.5			6.625	
ID		0.622			0.824			1.049			1.38			1.61			2.067			2.469			3.068			4.026			6.065	
Wall Thickness		0.109			0.113			0.133			0.14			0.145			0.154			0.203			0.216			0.237			0.28	
Area ID- SF		0.002			0.004			0.006			0.010			0.014			0.023			0.033			0.051			0.088			0.201	
Allowable Working Pressure (PSI)	Check Manufacturer				259			324			266			238			202			216		Check Manufacturer			Check Manufacturer			Check Manufacturer		
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	1.09	0.56	1.29	0.62	0.14	0.33	0.38	0.04	0.10	0.22	0.01	0.02	0.16	0.00	0.01	0.10	0.00	0.00	0.07	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00
2	2.18	2.02	4.67	1.24	0.51	1.19	0.77	0.16	0.37	0.44	0.04	0.08	0.33	0.02	0.04	0.20	0.01	0.01	0.14	0.00	0.00	0.09	0.00	0.00	0.05	0.00	0.00	0.02	0.00	0.00
3	3.27	4.28	9.90	1.86	1.09	2.52	1.15	0.34	0.78	0.66	0.08	0.18	0.49	0.04	0.08	0.30	0.01	0.02	0.21	0.00	0.01	0.13	0.00	0.00	0.08	0.00	0.00	0.03	0.00	0.00
4	4.36	7.30	16.86	2.48	1.86	4.29	1.53	0.57	1.32	0.89	0.13	0.30	0.65	0.06	0.14	0.39	0.02	0.04	0.28	0.01	0.02	0.18	0.00	0.01	0.10	0.00	0.00	0.05	0.00	0.00
5	5.45	11.04	25.49	3.11	2.81	6.48	1.92	0.87	2.00	1.11	0.20	0.46	0.81	0.09	0.22	0.49	0.03	0.06	0.35	0.01	0.03	0.22	0.00	0.01	0.13	0.00	0.00	0.06	0.00	0.00
6	Greater than 5 FPS			3.73	3.93	9.08	2.30	1.21	2.80	1.33	0.28	0.64	0.98	0.13	0.30	0.59	0.04	0.09	0.42	0.02	0.04	0.27	0.01	0.01	0.16	0.00	0.00	0.07	0.00	0.00
7				4.35	5.23	12.08	2.68	1.61	3.73	1.55	0.37	0.85	1.14	0.17	0.40	0.69	0.05	0.12	0.48	0.02	0.05	0.31	0.01	0.02	0.18	0.00	0.00	0.08	0.00	0.00
8				4.97	6.70	15.47	3.07	2.07	4.78	1.77	0.47	1.09	1.30	0.22	0.52	0.79	0.07	0.15	0.55	0.03	0.06	0.36	0.01	0.02	0.21	0.00	0.01	0.09	0.00	0.00
9				Greater than 5 FPS			3.45	2.57	5.94	1.99	0.59	1.36	1.46	0.28	0.64	0.89	0.08	0.19	0.62	0.03	0.08	0.40	0.01	0.02	0.23	0.00	0.01	0.10	0.00	0.00
10							3.83	3.13	7.22	2.21	0.72	1.66	1.63	0.34	0.78	0.99	0.10	0.23	0.69	0.04	0.10	0.45	0.01	0.03	0.26	0.00	0.01	0.11	0.00	0.00
12							4.60	4.38	10.12	2.66	1.00	2.32	1.95	0.47	1.10	1.18	0.14	0.32	0.83	0.06	0.14	0.54	0.02	0.04	0.31	0.00	0.01	0.14	0.00	0.00
14							Greater than 5 FPS			3.10	1.34	3.09	2.28	0.63	1.46	1.38	0.19	0.43	0.97	0.08	0.18	0.63	0.02	0.06	0.36	0.01	0.01	0.16	0.00	0.00
16										3.54	1.71	3.95	2.60	0.81	1.87	1.58	0.24	0.55	1.11	0.10	0.23	0.72	0.03	0.07	0.42	0.01	0.02	0.18	0.00	0.00
18										3.99	2.13	4.92	2.93	1.00	2.32	1.78	0.30	0.69	1.25	0.13	0.29	0.81	0.04	0.09	0.47	0.01	0.02	0.21	0.00	0.00
20										4.43	2.59	5.98	3.25	1.22	2.82	1.97	0.36	0.84	1.38	0.15	0.35	0.90	0.05	0.11	0.52	0.01	0.03	0.23	0.00	0.00
22										4.87	3.09	7.13	3.58	1.46	3.36	2.17	0.43	1.00	1.52	0.18	0.42	0.99	0.06	0.13	0.57	0.01	0.03	0.25	0.00	0.00
24										Greater than 5 FPS			3.90	1.71	3.95	2.37	0.51	1.17	1.66	0.21	0.49	1.08	0.07	0.15	0.62	0.02	0.04	0.28	0.00	0.01
26													4.23	1.98	4.58	2.57	0.59	1.36	1.80	0.25	0.57	1.16	0.08	0.17	0.68	0.02	0.05	0.30	0.00	0.01
28													4.56	2.28	5.26	2.76	0.67	1.56	1.94	0.28	0.66	1.25	0.09	0.20	0.73	0.02	0.05	0.32	0.00	0.01
30													4.88	2.59	5.98	2.96	0.77	1.77	2.08	0.32	0.74	1.34	0.10	0.23	0.78	0.03	0.06	0.34	0.00	0.01
35													Greater than 5 FPS			3.45	1.02	2.35	2.42	0.43	0.99	1.57	0.13	0.30	0.91	0.03	0.08	0.40	0.00	0.01
40																3.95	1.31	3.02	2.77	0.55	1.27	1.79	0.17	0.39	1.04	0.04	0.10	0.46	0.01	0.01
45																4.44	1.62	3.75	3.11	0.68	1.58	2.02	0.21	0.48	1.17	0.06	0.13	0.52	0.01	0.02
50																4.94	1.97	4.56	3.46	0.83	1.92	2.24	0.25	0.59	1.30	0.07	0.16	0.57	0.01	0.02
55																Greater than 5 FPS			3.80	0.99	2.29	2.46	0.30	0.70	1.43	0.08	0.19	0.63	0.01	0.03
60																			4.15	1.16	2.69	2.69	0.36	0.82	1.56	0.09	0.22	0.69	0.01	0.03
65																			4.50	1.35	3.12	2.91	0.41	0.95	1.69	0.11	0.25	0.75	0.01	0.03
70																			4.84	1.55	3.58	3.14	0.47	1.09	1.82	0.13	0.29	0.80	0.02	0.04
75																			Greater than 5 FPS			3.36	0.54	1.24	1.95	0.14	0.33	0.86	0.02	0.04
80																						3.58	0.61	1.40	2.08	0.16	0.37	0.92	0.02	0.05
85																						3.81	0.68	1.57	2.21	0.18	0.42	0.97	0.02	0.06
90																						4.03	0.75	1.74	2.34	0.20	0.46	1.03	0.03	0.06
95																						4.26	0.83	1.92	2.47	0.22	0.51	1.09	0.03	0.07
100																						4.48	0.92	2.12	2.60	0.24	0.56	1.15	0.03	0.08

Table 2 Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
110																						4.93	1.09	2.52	2.86	0.29	0.67	1.26	0.04	0.09
120																						Greater than 5 FPS			3.12	0.34	0.79	1.38	0.05	0.11
130																									3.38	0.40	0.92	1.49	0.05	0.12
140																									3.64	0.45	1.05	1.61	0.06	0.14
150																									3.90	0.52	1.19	1.72	0.07	0.16
160																									4.16	0.58	1.35	1.83	0.08	0.18
170																									4.42	0.65	1.51	1.95	0.09	0.20
180																									4.68	0.72	1.67	2.06	0.10	0.23
190																									4.94	0.80	1.85	2.18	0.11	0.25
200																									Greater than 5 FPS			2.29	0.12	0.28
220																												2.52	0.14	0.33
240																												2.75	0.17	0.39
260																												2.98	0.19	0.45
280																												3.21	0.22	0.52
300																												3.44	0.25	0.59
320																												3.67	0.29	0.66
340																												3.90	0.32	0.74
360																												4.13	0.36	0.82
380																												4.36	0.39	0.91
400																												4.59	0.43	1.00
420																												4.82	0.47	1.09
																												Greater than 5 FPS		

PIPELINE FRICTION LOSS TABLES: Table 3

SCH 80 PVC non-Threaded Plastic Pipe Friction Loss Characteristics for ASTM D1785 materials; Allowable pipe pressure design 72% of rated PSI at 43.48 F varies. Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 3b4), D= ID of pipe (inches), L=100 (ft).

PVC Sch 80 Iron Pipe Size (IPS) Plastic Pipe (D-1785); variable pressure rating

C=		130			130			130			140			140			140			140			150			150			150	
SIZE "		1/2			3/4			1			1 1/4			1 1/2			2			2 1/2			3			4			6	
ID		0.546			0.742			0.957			1.278			1.5			1.939			2.323			2.9			3.826			5.761	
Area ID- SF		0.002			0.003			0.005			0.009			0.012			0.021			0.029			0.046			0.080			0.181	
Allowable Working Pressure (PSI)		612			497			454			374			338			288			302			266		Check Manufacturer			Check Manufacturer		
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	1.41	1.06	2.44	0.77	0.24	0.55	0.46	0.07	0.16	0.26	0.01	0.03	0.19	0.01	0.02	0.11	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00
2	2.83	3.81	8.81	1.53	0.86	1.98	0.92	0.25	0.57	0.52	0.05	0.12	0.37	0.02	0.06	0.22	0.01	0.02	0.16	0.00	0.01	0.10	0.00	0.00	0.06	0.00	0.00	0.03	0.00	0.00
3	4.24	8.08	18.67	2.30	1.81	4.19	1.38	0.53	1.21	0.77	0.11	0.26	0.56	0.05	0.12	0.34	0.01	0.03	0.23	0.01	0.01	0.15	0.00	0.00	0.09	0.00	0.00	0.04	0.00	0.00
4	Greater than 5 FPS			3.06	3.09	7.14	1.84	0.90	2.07	1.03	0.19	0.44	0.75	0.09	0.20	0.45	0.03	0.06	0.31	0.01	0.02	0.20	0.00	0.01	0.12	0.00	0.00	0.05	0.00	0.00
5				3.83	4.67	10.80	2.30	1.35	3.13	1.29	0.29	0.67	0.94	0.13	0.31	0.56	0.04	0.09	0.39	0.02	0.04	0.25	0.00	0.01	0.14	0.00	0.00	0.06	0.00	0.00
6				4.60	6.55	15.13	2.76	1.90	4.38	1.55	0.40	0.93	1.12	0.19	0.43	0.67	0.05	0.12	0.47	0.02	0.05	0.30	0.01	0.02	0.17	0.00	0.00	0.08	0.00	0.00
7				Greater than 5 FPS			3.22	2.52	5.83	1.81	0.54	1.24	1.31	0.25	0.57	0.79	0.07	0.16	0.55	0.03	0.07	0.35	0.01	0.02	0.20	0.00	0.01	0.09	0.00	0.00
8							3.68	3.23	7.47	2.07	0.69	1.59	1.50	0.32	0.73	0.90	0.09	0.21	0.63	0.04	0.09	0.40	0.01	0.03	0.23	0.00	0.01	0.10	0.00	0.00
9							4.14	4.02	9.29	2.32	0.86	1.98	1.69	0.39	0.91	1.01	0.11	0.26	0.70	0.05	0.11	0.45	0.01	0.03	0.26	0.00	0.01	0.11	0.00	0.00
10							4.60	4.89	11.29	2.58	1.04	2.41	1.87	0.48	1.10	1.12	0.14	0.32	0.78	0.06	0.13	0.50	0.02	0.04	0.29	0.00	0.01	0.13	0.00	0.00
12							Greater than 5 FPS			3.10	1.46	3.37	2.25	0.67	1.55	1.35	0.19	0.44	0.94	0.08	0.18	0.60	0.02	0.05	0.35	0.01	0.01	0.15	0.00	0.00
14										3.61	1.94	4.49	2.62	0.89	2.06	1.57	0.26	0.59	1.09	0.11	0.24	0.70	0.03	0.07	0.40	0.01	0.02	0.18	0.00	0.00
16										4.13	2.49	5.74	3.00	1.14	2.63	1.79	0.33	0.75	1.25	0.14	0.31	0.80	0.04	0.09	0.46	0.01	0.02	0.20	0.00	0.00
18										4.65	3.09	7.15	3.37	1.42	3.28	2.02	0.41	0.94	1.41	0.17	0.39	0.90	0.05	0.12	0.52	0.01	0.03	0.23	0.00	0.00
20										Greater than 5 FPS			3.75	1.72	3.98	2.24	0.49	1.14	1.56	0.20	0.47	1.00	0.06	0.14	0.58	0.02	0.04	0.25	0.00	0.00
22													4.12	2.06	4.75	2.47	0.59	1.36	1.72	0.24	0.56	1.10	0.07	0.17	0.63	0.02	0.04	0.28	0.00	0.01
24													4.50	2.42	5.58	2.69	0.69	1.60	1.88	0.29	0.66	1.20	0.09	0.20	0.69	0.02	0.05	0.30	0.00	0.01
26													4.87	2.80	6.47	2.92	0.80	1.85	2.03	0.33	0.77	1.30	0.10	0.23	0.75	0.03	0.06	0.33	0.00	0.01
28													Greater than 5 FPS			3.14	0.92	2.13	2.19	0.38	0.88	1.40	0.11	0.26	0.81	0.03	0.07	0.36	0.00	0.01
30																3.36	1.05	2.42	2.34	0.43	1.00	1.50	0.13	0.30	0.86	0.03	0.08	0.38	0.00	0.01
35																3.93	1.39	3.21	2.74	0.58	1.33	1.76	0.17	0.40	1.01	0.04	0.10	0.44	0.01	0.01
40																4.49	1.78	4.12	3.13	0.74	1.71	2.01	0.22	0.51	1.15	0.06	0.13	0.51	0.01	0.02
45																Greater than 5 FPS			3.52	0.92	2.12	2.26	0.27	0.63	1.30	0.07	0.16	0.57	0.01	0.02
50																			3.91	1.12	2.58	2.51	0.33	0.77	1.44	0.09	0.20	0.64	0.01	0.03
55																			4.30	1.33	3.08	2.76	0.40	0.92	1.58	0.10	0.24	0.70	0.01	0.03
60																			4.69	1.57	3.62	3.01	0.47	1.08	1.73	0.12	0.28	0.76	0.02	0.04
65																			Greater than 5 FPS			3.26	0.54	1.25	1.87	0.14	0.33	0.83	0.02	0.04
70																						3.51	0.62	1.44	2.02	0.16	0.37	0.89	0.02	0.05
75																						3.76	0.71	1.63	2.16	0.18	0.42	0.95	0.02	0.06
80																						4.01	0.80	1.84	2.30	0.21	0.48	1.02	0.03	0.07
85																						4.26	0.89	2.06	2.45	0.23	0.53	1.08	0.03	0.07
90																						4.51	0.99	2.29	2.59	0.26	0.59	1.14	0.04	0.08
95																						4.76	1.10	2.53	2.74	0.28	0.66	1.21	0.04	0.09
100																						Greater than 5 FPS			2.88	0.31	0.72	1.27	0.04	0.10

Table 3 Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
110																									3.17	0.37	0.86	1.40	0.05	0.12
120																									3.46	0.44	1.01	1.52	0.06	0.14
130																									3.75	0.51	1.17	1.65	0.07	0.16
140																									4.03	0.58	1.35	1.78	0.08	0.18
150																									4.32	0.66	1.53	1.91	0.09	0.21
160																									4.61	0.75	1.72	2.03	0.10	0.23
170																									4.90	0.84	1.93	2.16	0.11	0.26
180																									Greater than 5 FPS			2.29	0.13	0.29
190																												2.41	0.14	0.32
200																												2.54	0.15	0.36
220																												2.80	0.18	0.42
240																												3.05	0.22	0.50
260																												3.30	0.25	0.58
280																												3.56	0.29	0.66
300																												3.81	0.33	0.75
320																												4.07	0.37	0.85
340																												4.32	0.41	0.95
360																												4.57	0.46	1.05
380																												4.83	0.50	1.17
400																												Greater than 5 FPS		

PIPELINE FRICTION LOSS TABLES: Table 4

PVC SDR 13.5 Rated Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120; Allowable pipe pressure design 72% of rated PSI at 43.48 F =Pipe Pressure = 313, Allowable Working Pressure is 227 PSI;
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

C=		130			140			140			140			140			150			150			150			150			150		
SIZE "		1			1 1/4			1 1/2			2			2 1/2			3			3 1/2			4			5			6	
ID		1.1950			1.5320			1.7540			2.1930			2.6550			3.2300			3.6692			4.154			5.135			6.115	
Area ID- SF		0.008			0.013			0.017			0.026			0.038			0.057			0.073			0.09411			0.1438			0.2039	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	0.30	0.02	0.05	0.18	0.01	0.01	0.14	0.00	0.01	0.09	0.00	0.00	0.06	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00
2	0.59	0.08	0.19	0.36	0.02	0.05	0.27	0.01	0.03	0.18	0.00	0.01	0.12	0.00	0.00	0.08	0.00	0.00	0.06	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00
3	0.89	0.18	0.41	0.54	0.05	0.11	0.41	0.02	0.06	0.26	0.01	0.02	0.18	0.00	0.01	0.12	0.00	0.00	0.09	0.00	0.00	0.07	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00
4	1.18	0.30	0.70	0.72	0.08	0.18	0.55	0.04	0.09	0.35	0.01	0.03	0.24	0.01	0.01	0.16	0.00	0.00	0.13	0.00	0.00	0.10	0.00	0.00	0.06	0.00	0.00	0.05	0.00	0.00
5	1.48	0.46	1.06	0.90	0.12	0.27	0.69	0.06	0.14	0.44	0.02	0.05	0.30	0.01	0.02	0.20	0.00	0.01	0.16	0.00	0.00	0.12	0.00	0.00	0.08	0.00	0.00	0.06	0.00	0.00
6	1.77	0.64	1.48	1.08	0.17	0.39	0.82	0.09	0.20	0.53	0.03	0.07	0.36	0.01	0.03	0.24	0.00	0.01	0.19	0.00	0.00	0.15	0.00	0.00	0.10	0.00	0.00	0.07	0.00	0.00
7	2.07	0.85	1.97	1.26	0.22	0.51	0.96	0.11	0.27	0.61	0.04	0.09	0.42	0.02	0.04	0.28	0.01	0.01	0.22	0.00	0.01	0.17	0.00	0.00	0.11	0.00	0.00	0.08	0.00	0.00
8	2.36	1.09	2.52	1.44	0.28	0.66	1.10	0.15	0.34	0.70	0.05	0.11	0.48	0.02	0.05	0.32	0.01	0.02	0.25	0.00	0.01	0.20	0.00	0.00	0.13	0.00	0.00	0.09	0.00	0.00
9	2.66	1.36	3.14	1.62	0.35	0.82	1.23	0.18	0.42	0.79	0.06	0.14	0.54	0.02	0.06	0.36	0.01	0.02	0.28	0.00	0.01	0.22	0.00	0.01	0.14	0.00	0.00	0.10	0.00	0.00
10	2.95	1.65	3.81	1.80	0.43	0.99	1.37	0.22	0.51	0.88	0.07	0.17	0.60	0.03	0.07	0.40	0.01	0.02	0.31	0.01	0.01	0.24	0.00	0.01	0.16	0.00	0.00	0.11	0.00	0.00
12	3.54	2.31	5.35	2.16	0.60	1.39	1.64	0.31	0.72	1.05	0.10	0.24	0.72	0.04	0.10	0.49	0.01	0.03	0.38	0.01	0.02	0.29	0.00	0.01	0.19	0.00	0.00	0.14	0.00	0.00
14	4.13	3.08	7.11	2.52	0.80	1.85	1.92	0.41	0.96	1.23	0.14	0.32	0.84	0.06	0.13	0.57	0.02	0.04	0.44	0.01	0.02	0.34	0.01	0.01	0.22	0.00	0.00	0.16	0.00	0.00
16	4.72	3.94	9.11	2.87	1.03	2.37	2.19	0.53	1.23	1.40	0.18	0.41	0.96	0.07	0.16	0.65	0.02	0.06	0.50	0.01	0.03	0.39	0.01	0.02	0.26	0.00	0.01	0.18	0.00	0.00
18	Greater than 5 FPS			3.23	1.27	2.95	2.47	0.66	1.52	1.58	0.22	0.51	1.08	0.09	0.20	0.73	0.03	0.07	0.56	0.02	0.04	0.44	0.01	0.02	0.29	0.00	0.01	0.20	0.00	0.00
20				3.59	1.55	3.58	2.74	0.80	1.85	1.75	0.27	0.62	1.20	0.11	0.25	0.81	0.04	0.08	0.63	0.02	0.04	0.49	0.01	0.02	0.32	0.00	0.01	0.23	0.00	0.00
22				3.95	1.85	4.27	3.02	0.96	2.21	1.93	0.32	0.74	1.32	0.13	0.29	0.89	0.04	0.10	0.69	0.02	0.05	0.54	0.01	0.03	0.35	0.00	0.01	0.25	0.00	0.00
24				4.31	2.17	5.02	3.29	1.12	2.60	2.10	0.38	0.87	1.44	0.15	0.34	0.97	0.05	0.12	0.75	0.03	0.06	0.59	0.01	0.03	0.38	0.01	0.01	0.27	0.00	0.01
26				4.67	2.52	5.82	3.56	1.30	3.01	2.28	0.44	1.01	1.56	0.17	0.40	1.05	0.06	0.14	0.81	0.03	0.07	0.64	0.02	0.04	0.42	0.01	0.01	0.29	0.00	0.01
28				Greater than 5 FPS			3.84	1.50	3.45	2.46	0.50	1.16	1.68	0.20	0.46	1.13	0.07	0.16	0.88	0.04	0.08	0.68	0.02	0.05	0.45	0.01	0.02	0.32	0.00	0.01
30							4.11	1.70	3.92	2.63	0.57	1.32	1.79	0.23	0.52	1.21	0.08	0.18	0.94	0.04	0.09	0.73	0.02	0.05	0.48	0.01	0.02	0.34	0.00	0.01
35							4.80	2.26	5.22	3.07	0.76	1.76	2.09	0.30	0.69	1.41	0.10	0.23	1.10	0.05	0.13	0.86	0.03	0.07	0.56	0.01	0.02	0.39	0.00	0.01
40							Greater than 5 FPS			3.51	0.98	2.25	2.39	0.38	0.89	1.62	0.13	0.30	1.25	0.07	0.16	0.98	0.04	0.09	0.64	0.01	0.03	0.45	0.01	0.01
45										3.95	1.21	2.80	2.69	0.48	1.10	1.82	0.16	0.37	1.41	0.09	0.20	1.10	0.05	0.11	0.72	0.02	0.04	0.51	0.01	0.02
50										4.38	1.47	3.41	2.99	0.58	1.34	2.02	0.20	0.45	1.57	0.11	0.24	1.22	0.06	0.13	0.80	0.02	0.05	0.56	0.01	0.02
55										4.82	1.76	4.06	3.29	0.69	1.60	2.22	0.23	0.54	1.72	0.13	0.29	1.34	0.07	0.16	0.88	0.02	0.06	0.62	0.01	0.02
60										Greater than 5 FPS			3.59	0.81	1.88	2.43	0.28	0.64	1.88	0.15	0.34	1.47	0.08	0.19	0.96	0.03	0.07	0.68	0.01	0.03
65													3.89	0.94	2.18	2.63	0.32	0.74	2.04	0.17	0.40	1.59	0.09	0.22	1.04	0.03	0.08	0.73	0.01	0.03
70													4.19	1.08	2.50	2.83	0.37	0.85	2.19	0.20	0.46	1.71	0.11	0.25	1.12	0.04	0.09	0.79	0.02	0.04
75													4.49	1.23	2.84	3.03	0.42	0.96	2.35	0.22	0.52	1.83	0.12	0.28	1.20	0.04	0.10	0.85	0.02	0.04
80													4.79	1.39	3.21	3.23	0.47	1.09	2.51	0.25	0.58	1.96	0.14	0.32	1.28	0.05	0.11	0.90	0.02	0.05
85													Greater than 5 FPS			3.44	0.53	1.21	2.66	0.28	0.65	2.08	0.15	0.36	1.36	0.06	0.13	0.96	0.02	0.05
90																3.64	0.58	1.35	2.82	0.31	0.73	2.20	0.17	0.40	1.44	0.06	0.14	1.01	0.03	0.06
95																3.84	0.65	1.49	2.98	0.35	0.80	2.32	0.19	0.44	1.52	0.07	0.16	1.07	0.03	0.07
100																4.04	0.71	1.64	3.13	0.38	0.88	2.44	0.21	0.48	1.60	0.07	0.17	1.13	0.03	0.07

Table 4 Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
110																4.45	0.85	1.96	3.45	0.46	1.05	2.69	0.25	0.58	1.76	0.09	0.20	1.24	0.04	0.09
120																4.85	1.00	2.30	3.76	0.54	1.24	2.93	0.29	0.68	1.92	0.10	0.24	1.35	0.04	0.10
130																Greater than 5 FPS			4.07	0.62	1.43	3.18	0.34	0.78	2.08	0.12	0.28	1.47	0.05	0.12
140																			4.39	0.71	1.65	3.42	0.39	0.90	2.24	0.14	0.32	1.58	0.06	0.14
150																			4.70	0.81	1.87	3.67	0.44	1.02	2.40	0.16	0.36	1.69	0.07	0.16
160																			Greater than 5 FPS			3.91	0.50	1.15	2.56	0.18	0.41	1.80	0.08	0.18
170																						4.15	0.56	1.29	2.72	0.20	0.46	1.92	0.08	0.20
180																						4.40	0.62	1.43	2.88	0.22	0.51	2.03	0.09	0.22
190																						4.64	0.69	1.58	3.04	0.24	0.56	2.14	0.10	0.24
200																						4.89	0.75	1.74	3.20	0.27	0.62	2.26	0.11	0.26
210																						Greater than 5 FPS			3.36	0.29	0.68	2.37	0.13	0.29
220																									3.52	0.32	0.74	2.48	0.14	0.32
230																									3.68	0.35	0.80	2.59	0.15	0.34
240																									3.84	0.38	0.87	2.71	0.16	0.37
250																									4.00	0.41	0.94	2.82	0.17	0.40
260																									4.16	0.44	1.01	2.93	0.19	0.43
270																									4.32	0.47	1.08	3.04	0.20	0.46
280																									4.48	0.50	1.16	3.16	0.21	0.49
290																									4.64	0.53	1.23	3.27	0.23	0.53
300																									4.80	0.57	1.31	3.38	0.24	0.56
310																									4.96	0.60	1.40	3.50	0.26	0.60
320																									Greater than 5 FPS			3.61	0.27	0.63
330																												3.72	0.29	0.67
340																												3.83	0.31	0.71
350																												3.95	0.32	0.75
360																												4.06	0.34	0.79
370																												4.17	0.36	0.83
380																												4.29	0.38	0.87
390																												4.40	0.39	0.91
400																												4.51	0.41	0.96
410																												4.62	0.57	1.00
420																												4.74	0.59	1.05
430																												4.85	0.62	1.09

PIPELINE FRICTION LOSS TABLES: Table 5

PVC SDR 17 Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120; Allowable pipe pressure design 72% of rated PSI at 43.48 F Allowable Working Pressure is 180 PSI. Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

C=		130			140			140			140			140			150			150			150			150	
SIZE "		1			1 1/4			1 1/2			2			2 1/2			3			4			6			8	
ID		1.16			1.46			1.68			2.10			2.54			3.09			3.97			5.85			7.61	
Area ID- SF		0.007			0.012			0.015			0.024			0.035			0.052			0.08596			0.1863			0.3158	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	0.31	0.03	0.06	0.20	0.01	0.02	0.15	0.00	0.01	0.10	0.00	0.00	0.07	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
2	0.62	0.10	0.22	0.39	0.03	0.06	0.30	0.01	0.03	0.19	0.00	0.01	0.13	0.00	0.00	0.09	0.00	0.00	0.05	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00
3	0.94	0.20	0.47	0.59	0.06	0.13	0.45	0.03	0.07	0.29	0.01	0.02	0.20	0.00	0.01	0.13	0.00	0.00	0.08	0.00	0.00	0.04	0.00	0.00	0.02	0.00	0.00
4	1.25	0.35	0.80	0.79	0.10	0.23	0.60	0.05	0.12	0.38	0.02	0.04	0.26	0.01	0.02	0.18	0.00	0.01	0.11	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00
5	1.56	0.52	1.21	0.98	0.15	0.34	0.75	0.08	0.18	0.48	0.03	0.06	0.33	0.01	0.02	0.22	0.00	0.01	0.13	0.00	0.00	0.06	0.00	0.00	0.04	0.00	0.00
6	1.87	0.73	1.70	1.18	0.21	0.48	0.90	0.11	0.25	0.58	0.04	0.08	0.39	0.01	0.03	0.27	0.00	0.01	0.16	0.00	0.00	0.07	0.00	0.00	0.04	0.00	0.00
7	2.19	0.98	2.26	1.38	0.28	0.64	1.05	0.14	0.33	0.67	0.05	0.11	0.46	0.02	0.04	0.31	0.01	0.01	0.19	0.00	0.00	0.09	0.00	0.00	0.05	0.00	0.00
8	2.50	1.25	2.89	1.57	0.35	0.82	1.20	0.18	0.42	0.77	0.06	0.14	0.52	0.02	0.06	0.35	0.01	0.02	0.21	0.00	0.01	0.10	0.00	0.00	0.06	0.00	0.00
9	2.81	1.56	3.60	1.77	0.44	1.02	1.35	0.23	0.53	0.86	0.08	0.18	0.59	0.03	0.07	0.40	0.01	0.02	0.24	0.00	0.01	0.11	0.00	0.00	0.07	0.00	0.00
10	3.12	1.89	4.37	1.97	0.54	1.24	1.50	0.28	0.64	0.96	0.09	0.22	0.66	0.04	0.09	0.44	0.01	0.03	0.27	0.00	0.01	0.12	0.00	0.00	0.07	0.00	0.00
12	3.75	2.65	6.13	2.36	0.75	1.73	1.80	0.39	0.90	1.15	0.13	0.30	0.79	0.05	0.12	0.53	0.02	0.04	0.32	0.01	0.01	0.15	0.00	0.00	0.09	0.00	0.00
14	4.37	3.53	8.15	2.75	1.00	2.31	2.10	0.52	1.19	1.35	0.17	0.40	0.92	0.07	0.16	0.62	0.02	0.05	0.37	0.01	0.02	0.17	0.00	0.00	0.10	0.00	0.00
16	5.00	4.52	10.44	3.15	1.28	2.95	2.40	0.66	1.53	1.54	0.22	0.52	1.05	0.09	0.20	0.71	0.03	0.07	0.43	0.01	0.02	0.20	0.00	0.00	0.12	0.00	0.00
18	Greater than 5 FPS			3.54	1.59	3.67	2.70	0.82	1.90	1.73	0.28	0.64	1.18	0.11	0.25	0.80	0.04	0.09	0.48	0.01	0.03	0.22	0.00	0.00	0.13	0.00	0.00
20				3.94	1.93	4.47	3.00	1.00	2.31	1.92	0.34	0.78	1.31	0.13	0.31	0.88	0.04	0.10	0.54	0.01	0.03	0.25	0.00	0.00	0.15	0.00	0.00
22				4.33	2.31	5.33	3.30	1.19	2.76	2.11	0.40	0.93	1.44	0.16	0.37	0.97	0.05	0.12	0.59	0.02	0.04	0.27	0.00	0.01	0.16	0.00	0.00
24				4.72	2.71	6.26	3.60	1.40	3.24	2.31	0.47	1.09	1.57	0.19	0.43	1.06	0.06	0.15	0.64	0.02	0.04	0.30	0.00	0.01	0.17	0.00	0.00
26				Greater than 5 FPS			3.90	1.63	3.76	2.50	0.55	1.27	1.70	0.22	0.50	1.15	0.07	0.17	0.70	0.02	0.05	0.32	0.00	0.01	0.19	0.00	0.00
28				Greater than 5 FPS			4.20	1.87	4.31	2.69	0.63	1.45	1.83	0.25	0.57	1.24	0.08	0.19	0.75	0.02	0.06	0.35	0.00	0.01	0.20	0.00	0.00
30				Greater than 5 FPS			4.50	2.12	4.90	2.88	0.72	1.65	1.97	0.28	0.65	1.33	0.10	0.22	0.80	0.03	0.06	0.37	0.00	0.01	0.22	0.00	0.00
35							Greater than 5 FPS			3.36	0.95	2.20	2.29	0.37	0.87	1.55	0.13	0.29	0.94	0.04	0.09	0.43	0.01	0.01	0.25	0.00	0.00
40							Greater than 5 FPS			3.84	1.22	2.81	2.62	0.48	1.11	1.77	0.16	0.37	1.07	0.05	0.11	0.49	0.01	0.02	0.29	0.00	0.00
45							Greater than 5 FPS			4.32	1.52	3.50	2.95	0.60	1.38	1.99	0.20	0.47	1.20	0.06	0.14	0.56	0.01	0.02	0.33	0.00	0.01
50							Greater than 5 FPS			4.80	1.84	4.25	3.28	0.73	1.67	2.21	0.25	0.57	1.34	0.07	0.17	0.62	0.01	0.03	0.36	0.00	0.01
55										Greater than 5 FPS			3.60	0.87	2.00	2.43	0.29	0.68	1.47	0.09	0.20	0.68	0.01	0.03	0.40	0.00	0.01
60													3.93	1.02	2.35	2.65	0.34	0.79	1.61	0.10	0.23	0.74	0.02	0.04	0.44	0.00	0.01
65													4.26	1.18	2.72	2.87	0.40	0.92	1.74	0.12	0.27	0.80	0.02	0.04	0.47	0.00	0.01
70													4.59	1.35	3.12	3.10	0.46	1.06	1.87	0.13	0.31	0.86	0.02	0.05	0.51	0.01	0.01
75													4.91	1.54	3.55	3.32	0.52	1.20	2.01	0.15	0.35	0.93	0.02	0.05	0.55	0.01	0.01
80													Greater than 5 FPS			3.54	0.59	1.35	2.14	0.17	0.40	0.99	0.03	0.06	0.58	0.01	0.02
85																3.76	0.65	1.51	2.27	0.19	0.44	1.05	0.03	0.07	0.62	0.01	0.02
90																3.98	0.73	1.68	2.41	0.21	0.49	1.11	0.03	0.08	0.66	0.01	0.02
95																4.20	0.80	1.86	2.54	0.24	0.55	1.17	0.04	0.08	0.69	0.01	0.02
100																4.42	0.88	2.04	2.68	0.26	0.60	1.23	0.04	0.09	0.73	0.01	0.03

table 5 Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
110																4.86	1.06	2.44	2.94	0.31	0.72	1.36	0.05	0.11	0.80	0.01	0.03
120																Greater than 5 FPS			3.21	0.36	0.84	1.48	0.06	0.13	0.87	0.02	0.04
130																			3.48	0.42	0.98	1.60	0.06	0.15	0.95	0.02	0.04
140																			3.75	0.49	1.12	1.73	0.07	0.17	1.02	0.02	0.05
150																			4.01	0.55	1.27	1.85	0.08	0.19	1.09	0.02	0.05
160																			4.28	0.62	1.44	1.97	0.09	0.22	1.17	0.03	0.06
170																			4.55	0.70	1.61	2.10	0.11	0.24	1.24	0.03	0.07
180																			4.82	0.77	1.79	2.22	0.12	0.27	1.31	0.03	0.08
190																			Greater than 5 FPS			2.35	0.13	0.30	1.38	0.04	0.08
200																						2.47	0.14	0.33	1.46	0.04	0.09
210																						2.59	0.16	0.36	1.53	0.04	0.10
220																						2.72	0.17	0.39	1.60	0.05	0.11
230																						2.84	0.18	0.43	1.68	0.05	0.12
240																						2.96	0.20	0.46	1.75	0.06	0.13
250																						3.09	0.22	0.50	1.82	0.06	0.14
260																						3.21	0.23	0.54	1.89	0.06	0.15
270																						3.33	0.25	0.58	1.97	0.07	0.16
280																						3.46	0.27	0.62	2.04	0.07	0.17
290																						3.58	0.28	0.66	2.11	0.08	0.18
300																						3.70	0.30	0.70	2.19	0.08	0.19
310																						3.83	0.32	0.74	2.26	0.09	0.21
320																						3.95	0.34	0.79	2.33	0.09	0.22
330																						4.07	0.36	0.83	2.40	0.10	0.23
340																						4.20	0.38	0.88	2.48	0.11	0.24
350																						4.32	0.40	0.93	2.55	0.11	0.26
360																						4.44	0.42	0.98	2.62	0.12	0.27
370																						4.57	0.45	1.03	2.70	0.12	0.29
380																						4.69	0.47	1.08	2.77	0.13	0.30
390																						4.81	0.49	1.14	2.84	0.14	0.31
400																						4.94	0.52	1.19	2.91	0.14	0.33

PIPELINE FRICTION LOSS TABLES: Table 6

PVC SDR 21 Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120; Allowable Pipe Working Pressure is 72% of rated PSI at 43.48 F. =144 PSI. 1 PSI= 2.31 FT.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

C=		130			140			140			140			140			150			150			150			150	
SIZE "		1			1 1/4			1 1/2			2			2 1/2			3			3.5			4			5	
ID		1.198			1.502			1.720			2.1			2.6			3.2			3.62			4.07			5.033	
Area ID- SF		0.008			0.012			0.016			0.025			0.037			0.055			0.071			0.090			0.138	
Flow GPM	Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/ 100'
1	0.29	0.02	0.05	0.19	0.01	0.02	0.14	0.00	0.01	0.09	0.00	0.00	0.06	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00
2	0.59	0.08	0.19	0.37	0.02	0.06	0.29	0.01	0.03	0.18	0.00	0.01	0.12	0.00	0.00	0.08	0.00	0.00	0.06	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00
3	0.88	0.18	0.41	0.56	0.05	0.12	0.43	0.03	0.06	0.27	0.01	0.02	0.19	0.00	0.01	0.13	0.00	0.00	0.10	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00
4	1.18	0.30	0.69	0.75	0.09	0.20	0.57	0.04	0.10	0.37	0.02	0.03	0.25	0.01	0.01	0.17	0.00	0.00	0.13	0.00	0.00	0.10	0.00	0.00	0.07	0.00	0.00
5	1.47	0.45	1.04	0.93	0.13	0.30	0.71	0.07	0.16	0.46	0.02	0.05	0.31	0.01	0.02	0.21	0.00	0.01	0.16	0.00	0.00	0.13	0.00	0.00	0.08	0.00	0.00
6	1.76	0.63	1.46	1.12	0.18	0.42	0.86	0.09	0.22	0.55	0.03	0.07	0.37	0.01	0.03	0.25	0.00	0.01	0.19	0.00	0.01	0.15	0.00	0.00	0.10	0.00	0.00
7	2.06	0.84	1.95	1.31	0.24	0.56	1.00	0.13	0.29	0.64	0.04	0.10	0.44	0.02	0.04	0.29	0.01	0.01	0.23	0.00	0.01	0.18	0.00	0.00	0.12	0.00	0.00
8	2.35	1.08	2.49	1.50	0.31	0.72	1.14	0.16	0.37	0.73	0.05	0.13	0.50	0.02	0.05	0.34	0.01	0.02	0.26	0.00	0.01	0.20	0.00	0.00	0.13	0.00	0.00
9	2.64	1.34	3.10	1.68	0.39	0.90	1.28	0.20	0.46	0.82	0.07	0.16	0.56	0.03	0.06	0.38	0.01	0.02	0.29	0.00	0.01	0.23	0.00	0.01	0.15	0.00	0.00
10	2.94	1.63	3.77	1.87	0.47	1.09	1.43	0.24	0.56	0.91	0.08	0.19	0.62	0.03	0.08	0.42	0.01	0.03	0.32	0.01	0.01	0.25	0.00	0.01	0.17	0.00	0.00
12	3.53	2.29	5.28	2.24	0.66	1.53	1.71	0.34	0.79	1.10	0.12	0.27	0.75	0.05	0.11	0.50	0.02	0.04	0.39	0.01	0.02	0.31	0.00	0.01	0.20	0.00	0.00
14	4.11	3.04	7.03	2.62	0.88	2.04	2.00	0.46	1.05	1.28	0.15	0.36	0.87	0.06	0.14	0.59	0.02	0.05	0.45	0.01	0.02	0.36	0.01	0.01	0.23	0.00	0.00
16	4.70	3.89	9.00	2.99	1.13	2.61	2.28	0.58	1.35	1.46	0.20	0.46	1.00	0.08	0.18	0.67	0.03	0.06	0.51	0.01	0.03	0.41	0.01	0.02	0.27	0.00	0.01
18	Greater than 5 FPS			3.36	1.40	3.24	2.57	0.73	1.68	1.64	0.25	0.57	1.12	0.10	0.22	0.76	0.03	0.08	0.58	0.02	0.04	0.46	0.01	0.02	0.30	0.00	0.01
20				3.74	1.71	3.94	2.85	0.88	2.04	1.83	0.30	0.69	1.25	0.12	0.27	0.84	0.04	0.09	0.64	0.02	0.05	0.51	0.01	0.03	0.33	0.00	0.01
22				4.11	2.04	4.70	3.14	1.05	2.43	2.01	0.36	0.82	1.37	0.14	0.32	0.93	0.05	0.11	0.71	0.02	0.06	0.56	0.01	0.03	0.37	0.00	0.01
24				4.49	2.39	5.52	3.42	1.24	2.86	2.19	0.42	0.97	1.50	0.16	0.38	1.01	0.06	0.13	0.77	0.03	0.07	0.61	0.02	0.04	0.40	0.01	0.01
26				4.86	2.77	6.41	3.71	1.43	3.31	2.37	0.48	1.12	1.62	0.19	0.44	1.09	0.06	0.15	0.84	0.03	0.08	0.66	0.02	0.04	0.43	0.01	0.02
28				Greater than 5 FPS			3.99	1.64	3.80	2.56	0.56	1.28	1.75	0.22	0.51	1.18	0.07	0.17	0.90	0.04	0.09	0.71	0.02	0.05	0.47	0.01	0.02
30							4.28	1.87	4.32	2.74	0.63	1.46	1.87	0.25	0.58	1.26	0.08	0.19	0.97	0.04	0.10	0.76	0.02	0.06	0.50	0.01	0.02
35							4.99	2.49	5.74	3.20	0.84	1.94	2.18	0.33	0.77	1.47	0.11	0.26	1.13	0.06	0.13	0.89	0.03	0.08	0.58	0.01	0.03
40							Greater than 5 FPS			3.65	1.08	2.49	2.49	0.42	0.98	1.68	0.14	0.33	1.29	0.07	0.17	1.02	0.04	0.10	0.67	0.02	0.03
45										4.11	1.34	3.09	2.81	0.53	1.22	1.89	0.18	0.41	1.45	0.09	0.21	1.14	0.05	0.12	0.75	0.02	0.04
50										4.57	1.63	3.76	3.12	0.64	1.48	2.10	0.22	0.50	1.61	0.11	0.26	1.27	0.06	0.15	0.83	0.02	0.05
55										5.02	1.94	4.48	3.43	0.77	1.77	2.31	0.26	0.60	1.77	0.13	0.31	1.40	0.08	0.18	0.92	0.03	0.06
60										Greater than 5 FPS			3.74	0.90	2.08	2.52	0.30	0.70	1.93	0.16	0.37	1.53	0.09	0.21	1.00	0.03	0.07
65													4.05	1.04	2.41	2.73	0.35	0.81	2.09	0.18	0.42	1.65	0.10	0.24	1.08	0.04	0.09
70													4.36	1.20	2.77	2.95	0.40	0.93	2.25	0.21	0.49	1.78	0.12	0.27	1.17	0.04	0.10
75													4.68	1.36	3.14	3.16	0.46	1.06	2.41	0.24	0.55	1.91	0.13	0.31	1.25	0.05	0.11
80													4.99	1.53	3.54	3.37	0.52	1.20	2.57	0.27	0.62	2.03	0.15	0.35	1.33	0.05	0.13
85													5.30	1.72	3.96	3.58	0.58	1.34	2.74	0.30	0.70	2.16	0.17	0.39	1.42	0.06	0.14
90													Greater than 5 FPS			3.79	0.64	1.49	2.90	0.34	0.78	2.29	0.19	0.44	1.50	0.07	0.16
95																4.00	0.71	1.65	3.06	0.37	0.86	2.42	0.21	0.48	1.58	0.07	0.17
100																4.21	0.78	1.81	3.22	0.41	0.94	2.54	0.23	0.53	1.66	0.08	0.19

Table 6 Flow GPM	Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/ 100'
110																4.63	0.93	2.16	3.54	0.49	1.12	2.80	0.27	0.63	1.83	0.10	0.23
120																Greater than 5 FPS			3.86	0.57	1.32	3.05	0.32	0.74	2.00	0.11	0.27
130																			4.18	0.66	1.53	3.31	0.37	0.86	2.16	0.13	0.31
140																			4.51	0.76	1.76	3.56	0.43	0.99	2.33	0.15	0.35
150																			4.83	0.86	2.00	3.81	0.49	1.13	2.50	0.17	0.40
160																			5.15	0.97	2.25	4.07	0.55	1.27	2.66	0.20	0.45
170																			5.47	1.09	2.52	4.32	0.61	1.42	2.83	0.22	0.51
180																			5.79	1.21	2.80	4.58	0.68	1.58	3.00	0.24	0.56
190																			Greater than 5 FPS			4.83	0.75	1.74	3.16	0.27	0.62
200																						Greater than 5 FPS			3.33	0.30	0.68
210																									3.50	0.32	0.75
220																									3.66	0.35	0.82
230																									3.83	0.38	0.89
240																									4.00	0.41	0.96
250																									4.16	0.45	1.03
260																									4.33	0.48	1.11
270																									4.49	0.52	1.19
280																									4.66	0.55	1.27
290																									4.83	0.59	1.36
300																									4.99	0.63	1.45
310																									Greater than 5 FPS		

PVC SDR 26 Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120; Allowable Pipe Working Pressure is 72% of rated PSI at 43.48 F. =115 PSI. 1 PSI= 2.31 FT.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

	130			140			140			130			150			150			150			150			150	
	1			1 1/4			1 1/2			2			2 1/2			3			4			5			6	
	1.1950			1.5320			1.7540			2.1930			2.6550			3.2300			4.154			5.135			6.115	
	0.008			0.013			0.017			0.026			0.038			0.057			0.09411			0.1438			0.2039	
Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel. FPS	PSI LOSS /100'	FT. LOSS/ 100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/100'	Vel FPS	PSI LOSS /100'	FT. LOSS /100'	Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/ 100'
0.30	0.02	0.05	0.18	0.01	0.01	0.14	0.00	0.01	0.09	0.00	0.00	0.06	0.00	0.00	0.04	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00
0.59	0.08	0.19	0.36	0.02	0.05	0.27	0.01	0.03	0.18	0.00	0.01	0.12	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00
0.89	0.18	0.41	0.54	0.05	0.11	0.41	0.02	0.06	0.26	0.01	0.02	0.18	0.00	0.01	0.12	0.00	0.00	0.07	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00
1.18	0.30	0.70	0.72	0.08	0.18	0.55	0.04	0.09	0.35	0.02	0.04	0.24	0.00	0.01	0.16	0.00	0.00	0.10	0.00	0.00	0.06	0.00	0.00	0.05	0.00	0.00
1.48	0.46	1.06	0.90	0.12	0.27	0.69	0.06	0.14	0.44	0.02	0.05	0.30	0.01	0.02	0.20	0.00	0.01	0.12	0.00	0.00	0.08	0.00	0.00	0.06	0.00	0.00
1.77	0.64	1.48	1.08	0.17	0.39	0.82	0.09	0.20	0.53	0.03	0.08	0.36	0.01	0.02	0.24	0.00	0.01	0.15	0.00	0.00	0.10	0.00	0.00	0.07	0.00	0.00
2.07	0.85	1.97	1.26	0.22	0.51	0.96	0.11	0.27	0.61	0.04	0.10	0.42	0.01	0.03	0.28	0.01	0.01	0.17	0.00	0.00	0.11	0.00	0.00	0.08	0.00	0.00
2.36	1.09	2.52	1.44	0.28	0.66	1.10	0.15	0.34	0.70	0.06	0.13	0.48	0.02	0.04	0.32	0.01	0.02	0.20	0.00	0.00	0.13	0.00	0.00	0.09	0.00	0.00
2.66	1.36	3.14	1.62	0.35	0.82	1.23	0.18	0.42	0.79	0.07	0.16	0.54	0.02	0.05	0.36	0.01	0.02	0.22	0.00	0.01	0.14	0.00	0.00	0.10	0.00	0.00
2.95	1.65	3.81	1.80	0.43	0.99	1.37	0.22	0.51	0.88	0.09	0.20	0.60	0.03	0.06	0.40	0.01	0.02	0.24	0.00	0.01	0.16	0.00	0.00	0.11	0.00	0.00
3.54	2.31	5.35	2.16	0.60	1.39	1.64	0.31	0.72	1.05	0.12	0.28	0.72	0.04	0.08	0.49	0.01	0.03	0.29	0.00	0.01	0.19	0.00	0.00	0.14	0.00	0.00
4.13	3.08	7.11	2.52	0.80	1.85	1.92	0.41	0.96	1.23	0.16	0.37	0.84	0.05	0.11	0.57	0.02	0.04	0.34	0.01	0.01	0.22	0.00	0.00	0.16	0.00	0.00
4.72	3.94	9.11	2.87	1.03	2.37	2.19	0.53	1.23	1.40	0.20	0.47	0.96	0.06	0.14	0.65	0.02	0.06	0.39	0.01	0.02	0.26	0.00	0.01	0.18	0.00	0.00
Greater than 5 FPS			3.23	1.27	2.95	2.47	0.66	1.52	1.58	0.25	0.59	1.08	0.08	0.18	0.73	0.03	0.07	0.44	0.01	0.02	0.29	0.00	0.01	0.20	0.00	0.00
			3.59	1.55	3.58	2.74	0.80	1.85	1.75	0.31	0.72	1.20	0.09	0.22	0.81	0.04	0.08	0.49	0.01	0.02	0.32	0.00	0.01	0.23	0.00	0.00
			3.95	1.85	4.27	3.02	0.96	2.21	1.93	0.37	0.85	1.32	0.11	0.26	0.89	0.04	0.10	0.54	0.01	0.03	0.35	0.00	0.01	0.25	0.00	0.00
			4.31	2.17	5.02	3.29	1.12	2.60	2.10	0.43	1.00	1.44	0.13	0.30	0.97	0.05	0.12	0.59	0.01	0.03	0.38	0.01	0.01	0.27	0.00	0.01
			4.67	2.52	5.82	3.56	1.30	3.01	2.28	0.50	1.16	1.56	0.15	0.35	1.05	0.06	0.14	0.64	0.02	0.04	0.42	0.01	0.01	0.29	0.00	0.01
			Greater than 5 FPS			3.84	1.50	3.45	2.46	0.58	1.33	1.68	0.17	0.40	1.13	0.07	0.16	0.68	0.02	0.05	0.45	0.01	0.02	0.32	0.00	0.01
						4.11	1.70	3.92	2.63	0.66	1.52	1.79	0.20	0.46	1.21	0.08	0.18	0.73	0.02	0.05	0.48	0.01	0.02	0.34	0.00	0.01
						4.80	2.26	5.22	3.07	0.87	2.02	2.09	0.26	0.61	1.41	0.10	0.23	0.86	0.03	0.07	0.56	0.01	0.02	0.39	0.00	0.01
						Greater than 5 FPS			3.51	1.12	2.58	2.39	0.34	0.78	1.62	0.13	0.30	0.98	0.04	0.09	0.64	0.01	0.03	0.45	0.01	0.01
									3.95	1.39	3.21	2.69	0.42	0.97	1.82	0.16	0.37	1.10	0.05	0.11	0.72	0.02	0.04	0.51	0.01	0.02
									4.38	1.69	3.91	2.99	0.51	1.18	2.02	0.20	0.45	1.22	0.06	0.13	0.80	0.02	0.05	0.56	0.01	0.02
									4.82	2.02	4.66	3.29	0.61	1.41	2.22	0.23	0.54	1.34	0.07	0.16	0.88	0.02	0.06	0.62	0.01	0.02
									Greater than 5 FPS			3.59	0.72	1.66	2.43	0.28	0.64	1.47	0.08	0.19	0.96	0.03	0.07	0.68	0.01	0.03
												3.89	0.83	1.92	2.63	0.32	0.74	1.59	0.09	0.22	1.04	0.03	0.08	0.73	0.01	0.03
												4.19	0.95	2.20	2.83	0.37	0.85	1.71	0.11	0.25	1.12	0.04	0.09	0.79	0.02	0.04
												4.49	1.08	2.50	3.03	0.42	0.96	1.83	0.12	0.28	1.20	0.04	0.10	0.85	0.02	0.04
												4.79	1.22	2.82	3.23	0.47	1.09	1.96	0.14	0.32	1.28	0.05	0.11	0.90	0.02	0.05
												Greater than 5 FPS			3.44	0.53	1.21	2.08	0.15	0.36	1.36	0.06	0.13	0.96	0.02	0.05
															3.64	0.58	1.35	2.20	0.17	0.40	1.44	0.06	0.14	1.01	0.03	0.06
															3.84	0.65	1.49	2.32	0.19	0.44	1.52	0.07	0.16	1.07	0.03	0.07
															4.04	0.71	1.64	2.44	0.21	0.48	1.60	0.07	0.17	1.13	0.03	0.07

Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/ 100'	Vel. FPS	PSI LOSS /100'	FT. LOSS/ 100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/100'	Vel FPS	PSI LOSS /100'	FT. LOSS /100'	Vel. FPS	PSI LOSS/100'	FT. LOSS /100'	Vel FPS	PSI LOSS/100'	FT. LOSS/100'	Vel. FPS	PSI LOSS/100'	FT. LOSS/ 100'
															4.45	0.85	1.96	2.69	0.25	0.58	1.76	0.09	0.20	1.24	0.04	0.09
															Greater than 5 FPS			2.93	0.29	0.68	1.92	0.10	0.24	1.35	0.04	0.10
																		3.18	0.34	0.78	2.08	0.12	0.28	1.47	0.05	0.12
																		3.42	0.39	0.90	2.24	0.14	0.32	1.58	0.06	0.14
																		3.67	0.44	1.02	2.40	0.16	0.36	1.69	0.07	0.16
																		3.91	0.50	1.15	2.56	0.18	0.41	1.80	0.08	0.18
																		4.15	0.56	1.29	2.72	0.20	0.46	1.92	0.08	0.20
																		4.40	0.62	1.43	2.88	0.22	0.51	2.03	0.09	0.22
																		4.64	0.69	1.58	3.04	0.24	0.56	2.14	0.10	0.24
																		4.89	0.75	1.74	3.20	0.27	0.62	2.26	0.11	0.26
																		Greater than 5 FPS			3.36	0.29	0.68	2.37	0.13	0.29
																					3.52	0.32	0.74	2.48	0.14	0.32
																					3.68	0.35	0.80	2.59	0.15	0.34
																					3.84	0.38	0.87	2.71	0.16	0.37
																					4.00	0.41	0.94	2.82	0.17	0.40
																					4.16	0.44	1.01	2.93	0.19	0.43
																					4.32	0.47	1.08	3.04	0.20	0.46
																					4.48	0.50	1.16	3.16	0.21	0.49
																					4.64	0.53	1.23	3.27	0.23	0.53
																					4.80	0.57	1.31	3.38	0.24	0.56
																					4.96	0.60	1.40	3.50	0.26	0.60
																					Greater than 5 FPS			3.61	0.27	0.63
																								3.72	0.29	0.67
																								3.83	0.31	0.71
																								3.95	0.32	0.75
																								4.06	0.34	0.79
																								4.17	0.36	0.83
																								4.29	0.38	0.87
																								4.40	0.39	0.91
																								4.51	0.41	0.96

PIPELINE

FRICTION LOSS PVC SDR 32.5 Rated Plastic Pipe Friction Loss Characteristics for ASTM D2241 materials 1120, 1220, 2120; Allowable Pipe Working Pressure is 72% of rated PSI at 43.48 F. =90 PSI. 1 PSI= 2.31 FT.

TABLES: Table 8 Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

Hazen Williams Friction Loss (ft.)/100 ft Part 623;Chapter 7, Microirrigation

$$hf\ (ft/100') = 10.536 \times \frac{Q(GPM)^{1.852}}{C^{1.852}} \times D(I.D.\ In.)^{(-4.871)} \times L\ (ft)$$

1 PSI= 2.31 FT

Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value

C=		130			140			140			140			140			150			150			150			150	
SIZE "		1			1 1/4			1 1/2			2			2 1/2			3			4			5			6	
ID		1.1950			1.5320			1.7540			2.1930			2.6550			3.2300			4.154			5.135			6.115	
Area ID- SF		0.008			0.013			0.017			0.026			0.038			0.057			0.09411			0.1438			0.2039	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	0.30	0.02	0.05	0.18	0.01	0.01	0.14	0.00	0.01	0.09	0.00	0.00	0.06	0.00	0.00	0.04	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00
2	0.59	0.08	0.19	0.36	0.02	0.05	0.27	0.01	0.03	0.18	0.00	0.01	0.12	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00
3	0.89	0.18	0.41	0.54	0.05	0.11	0.41	0.02	0.06	0.26	0.01	0.02	0.18	0.00	0.01	0.12	0.00	0.00	0.07	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00
4	1.18	0.30	0.70	0.72	0.08	0.18	0.55	0.04	0.09	0.35	0.01	0.03	0.24	0.01	0.01	0.16	0.00	0.00	0.10	0.00	0.00	0.06	0.00	0.00	0.05	0.00	0.00
5	1.48	0.46	1.06	0.90	0.12	0.27	0.69	0.06	0.14	0.44	0.02	0.05	0.30	0.01	0.02	0.20	0.00	0.01	0.12	0.00	0.00	0.08	0.00	0.00	0.06	0.00	0.00
6	1.77	0.64	1.48	1.08	0.17	0.39	0.82	0.09	0.20	0.53	0.03	0.07	0.36	0.01	0.03	0.24	0.00	0.01	0.15	0.00	0.00	0.10	0.00	0.00	0.07	0.00	0.00
7	2.07	0.85	1.97	1.26	0.22	0.51	0.96	0.11	0.27	0.61	0.04	0.09	0.42	0.02	0.04	0.28	0.01	0.01	0.17	0.00	0.00	0.11	0.00	0.00	0.08	0.00	0.00
8	2.36	1.09	2.52	1.44	0.28	0.66	1.10	0.15	0.34	0.70	0.05	0.11	0.48	0.02	0.05	0.32	0.01	0.02	0.20	0.00	0.00	0.13	0.00	0.00	0.09	0.00	0.00
9	2.66	1.36	3.14	1.62	0.35	0.82	1.23	0.18	0.42	0.79	0.06	0.14	0.54	0.02	0.06	0.36	0.01	0.02	0.22	0.00	0.01	0.14	0.00	0.00	0.10	0.00	0.00
10	2.95	1.65	3.81	1.80	0.43	0.99	1.37	0.22	0.51	0.88	0.07	0.17	0.60	0.03	0.07	0.40	0.01	0.02	0.24	0.00	0.01	0.16	0.00	0.00	0.11	0.00	0.00
12	3.54	2.31	5.35	2.16	0.60	1.39	1.64	0.31	0.72	1.05	0.10	0.24	0.72	0.04	0.10	0.49	0.01	0.03	0.29	0.00	0.01	0.19	0.00	0.00	0.14	0.00	0.00
14	4.13	3.08	7.11	2.52	0.80	1.85	1.92	0.41	0.96	1.23	0.14	0.32	0.84	0.06	0.13	0.57	0.02	0.04	0.34	0.01	0.01	0.22	0.00	0.00	0.16	0.00	0.00
16	4.72	3.94	9.11	2.87	1.03	2.37	2.19	0.53	1.23	1.40	0.18	0.41	0.96	0.07	0.16	0.65	0.02	0.06	0.39	0.01	0.02	0.26	0.00	0.01	0.18	0.00	0.00
18	Greater than 5 FPS			3.23	1.27	2.95	2.47	0.66	1.52	1.58	0.22	0.51	1.08	0.09	0.20	0.73	0.03	0.07	0.44	0.01	0.02	0.29	0.00	0.01	0.20	0.00	0.00
20				3.59	1.55	3.58	2.74	0.80	1.85	1.75	0.27	0.62	1.20	0.11	0.25	0.81	0.04	0.08	0.49	0.01	0.02	0.32	0.00	0.01	0.23	0.00	0.00
22				3.95	1.85	4.27	3.02	0.96	2.21	1.93	0.32	0.74	1.32	0.13	0.29	0.89	0.04	0.10	0.54	0.01	0.03	0.35	0.00	0.01	0.25	0.00	0.00
24				4.31	2.17	5.02	3.29	1.12	2.60	2.10	0.38	0.87	1.44	0.15	0.34	0.97	0.05	0.12	0.59	0.01	0.03	0.38	0.01	0.01	0.27	0.00	0.01
26				4.67	2.52	5.82	3.56	1.30	3.01	2.28	0.44	1.01	1.56	0.17	0.40	1.05	0.06	0.14	0.64	0.02	0.04	0.42	0.01	0.01	0.29	0.00	0.01
28				Greater than 5 FPS			3.84	1.50	3.45	2.46	0.50	1.16	1.68	0.20	0.46	1.13	0.07	0.16	0.68	0.02	0.05	0.45	0.01	0.02	0.32	0.00	0.01
30							4.11	1.70	3.92	2.63	0.57	1.32	1.79	0.23	0.52	1.21	0.08	0.18	0.73	0.02	0.05	0.48	0.01	0.02	0.34	0.00	0.01
35							4.80	2.26	5.22	3.07	0.76	1.76	2.09	0.30	0.69	1.41	0.10	0.23	0.86	0.03	0.07	0.56	0.01	0.02	0.39	0.00	0.01
40							Greater than 5 FPS			3.51	0.98	2.25	2.39	0.38	0.89	1.62	0.13	0.30	0.98	0.04	0.09	0.64	0.01	0.03	0.45	0.01	0.01
45										3.95	1.21	2.80	2.69	0.48	1.10	1.82	0.16	0.37	1.10	0.05	0.11	0.72	0.02	0.04	0.51	0.01	0.02
50										4.38	1.47	3.41	2.99	0.58	1.34	2.02	0.20	0.45	1.22	0.06	0.13	0.80	0.02	0.05	0.56	0.01	0.02
55										4.82	1.76	4.06	3.29	0.69	1.60	2.22	0.23	0.54	1.34	0.07	0.16	0.88	0.02	0.06	0.62	0.01	0.02
60										Greater than 5 FPS			3.59	0.81	1.88	2.43	0.28	0.64	1.47	0.08	0.19	0.96	0.03	0.07	0.68	0.01	0.03
65													3.89	0.94	2.18	2.63	0.32	0.74	1.59	0.09	0.22	1.04	0.03	0.08	0.73	0.01	0.03
70													4.19	1.08	2.50	2.83	0.37	0.85	1.71	0.11	0.25	1.12	0.04	0.09	0.79	0.02	0.04
75													4.49	1.23	2.84	3.03	0.42	0.96	1.83	0.12	0.28	1.20	0.04	0.10	0.85	0.02	0.04
80													4.79	1.39	3.21	3.23	0.47	1.09	1.96	0.14	0.32	1.28	0.05	0.11	0.90	0.02	0.05
85													Greater than 5 FPS			3.44	0.53	1.21	2.08	0.15	0.36	1.36	0.06	0.13	0.96	0.02	0.05
90																3.64	0.58	1.35	2.20	0.17	0.40	1.44	0.06	0.14	1.01	0.03	0.06
95																3.84	0.65	1.49	2.32	0.19	0.44	1.52	0.07	0.16	1.07	0.03	0.07
100																4.04	0.71	1.64	2.44	0.21	0.48	1.60	0.07	0.17	1.13	0.03	0.07

110																4.45	0.85	1.96	2.69	0.25	0.58	1.76	0.09	0.20	1.24	0.04	0.09
120																Greater than 5 FPS			2.93	0.29	0.68	1.92	0.10	0.24	1.35	0.04	0.10
130																			3.18	0.34	0.78	2.08	0.12	0.28	1.47	0.05	0.12
Table 8 Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
140																			3.42	0.39	0.90	2.24	0.14	0.32	1.58	0.06	0.14
150																			3.67	0.44	1.02	2.40	0.16	0.36	1.69	0.07	0.16
160																			3.91	0.50	1.15	2.56	0.18	0.41	1.80	0.08	0.18
170																			4.15	0.56	1.29	2.72	0.20	0.46	1.92	0.08	0.20
180																			4.40	0.62	1.43	2.88	0.22	0.51	2.03	0.09	0.22
190																			4.64	0.69	1.58	3.04	0.24	0.56	2.14	0.10	0.24
200																			4.89	0.75	1.74	3.20	0.27	0.62	2.26	0.11	0.26
210																			Greater than 5 FPS			3.36	0.29	0.68	2.37	0.13	0.29
220																						3.52	0.32	0.74	2.48	0.14	0.32
230																						3.68	0.35	0.80	2.59	0.15	0.34
240																						3.84	0.38	0.87	2.71	0.16	0.37
250																						4.00	0.41	0.94	2.82	0.17	0.40
260																						4.16	0.44	1.01	2.93	0.19	0.43
270																						4.32	0.47	1.08	3.04	0.20	0.46
280																						4.48	0.50	1.16	3.16	0.21	0.49
290																						4.64	0.53	1.23	3.27	0.23	0.53
300																						4.80	0.57	1.31	3.38	0.24	0.56
310																						4.96	0.60	1.40	3.50	0.26	0.60
320																						Greater than 5 FPS			3.61	0.27	0.63
330																									3.72	0.29	0.67
340																									3.83	0.31	0.71
350																									3.95	0.32	0.75
360																									4.06	0.34	0.79
370																									4.17	0.36	0.83
380																									4.29	0.38	0.87
390																									4.40	0.39	0.91
400																									4.51	0.41	0.96
410																									4.62	0.43	1.00
420																									4.74	0.45	1.05
430																									4.85	0.47	1.09
440																									4.96	0.49	1.14

PIPELINE FRICTION LOSS TABLES: Table 9

Polybutylene Water Service Pipe IPS- ID ASTM D2662, SDR 11.5; 160 PSI at 73.48 Deg. F. Allowable Pipe Working Pressure is 72% of rated PSI at 43.48 F. =115 PSI. 1 PSI= 2.31 FT.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).

C=		130			130			140			140			140	
SIZE "		3/4			1			1 1/4			1 1/2			2	
ID		0.8240			1.0490			1.3800			1.6100			2.0670	
Area ID- SF		0.004			0.006			0.010			0.014			0.023	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	0.62	0.14	0.33	0.38	0.04	0.10	0.22	0.01	0.02	0.16	0.00	0.01	0.10	0.00	0.00
2	1.24	0.51	1.18	0.77	0.16	0.37	0.44	0.04	0.08	0.33	0.02	0.04	0.20	0.01	0.01
3	1.86	1.09	2.51	1.15	0.33	0.77	0.66	0.08	0.18	0.49	0.04	0.08	0.30	0.01	0.02
4	2.48	1.85	4.27	1.53	0.57	1.32	0.89	0.13	0.30	0.65	0.06	0.14	0.39	0.02	0.04
5	3.11	2.80	6.46	1.92	0.86	1.99	1.11	0.20	0.46	0.81	0.09	0.22	0.49	0.03	0.06
6	3.73	3.92	9.05	2.30	1.21	2.79	1.33	0.28	0.64	0.98	0.13	0.30	0.59	0.04	0.09
7	4.35	5.21	12.04	2.68	1.61	3.72	1.55	0.37	0.85	1.14	0.17	0.40	0.69	0.05	0.12
8	4.97	6.68	15.42	3.07	2.06	4.76	1.77	0.47	1.09	1.30	0.22	0.52	0.79	0.07	0.15
9	Greater than 5 FPS			3.45	2.56	5.92	1.99	0.59	1.36	1.46	0.28	0.64	0.89	0.08	0.19
10				3.83	3.11	7.19	2.21	0.71	1.65	1.63	0.34	0.78	0.99	0.10	0.23
11				4.22	3.72	8.58	2.44	0.85	1.97	1.79	0.40	0.93	1.09	0.12	0.28
12				4.60	4.37	10.08	2.66	1.00	2.31	1.95	0.47	1.09	1.18	0.14	0.32
13				4.98	5.06	11.70	2.88	1.16	2.68	2.11	0.55	1.27	1.28	0.16	0.37
14				Greater than 5 FPS			3.10	1.33	3.08	2.28	0.63	1.45	1.38	0.19	0.43
16							3.54	1.71	3.94	2.60	0.80	1.86	1.58	0.24	0.55
18							3.99	2.12	4.90	2.93	1.00	2.31	1.78	0.30	0.68
20							4.43	2.58	5.95	3.25	1.22	2.81	1.97	0.36	0.83
22							4.87	3.08	7.10	3.58	1.45	3.35	2.17	0.43	0.99
24							Greater than 5 FPS			3.90	1.71	3.94	2.37	0.51	1.17
26										4.23	1.98	4.57	2.57	0.59	1.35
31										Greater than 5 FPS			3.06	0.81	1.87
36													3.55	1.07	2.47
41													4.05	1.36	3.15
46													4.54	1.69	3.89
51													Greater than 5 FPS		
56															

PIPELINE FRICTION LOSS TABLES: Table 10

Polybutylene Water Service Pipe CPS- ID ASTM D2662, SDR 9 250 PSI at 73.4 Deg. F. Allowable Pipe Working Pressure is =180 PSI. 1 PSI= 2.31 FT.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 13b), D= ID of pipe (inches), L=100 (ft).
hf = 10.536 x ((Q^ 1.852)/(C^1.852)) x (D^-4.871) x L(ft)

180 PSI

Hazen Williams Friction Loss (ft.)/100 ft Part 623;Chapter 7, Microirrigation

$$hf\ (ft/100') = 10.536 \times \frac{Q(GPM)^{1.852}}{C^{1.852}} \times D(I.D.\ In.)^{(-4.871)} \times L\ (ft)$$

1 PSI= 2.31 FT

Hazen Williams "C" Factor (Part 623 Irrigation, Chapter 7, Table 7-23) for Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" or lessor table value in Table 14), D= ID of pipe (inches), L=100 (ft).

C=		130			130			140			140			140	
SIZE "		3/4			1			1 1/4			1 1/2			2	
ID		0.6750			0.8650			1.0640			1.2590			1.6490	
Area ID- SF		0.002			0.004			0.006			0.009			0.015	
Flow GPM	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'	Velocity FPS	PSI LOSS/100'	FT. LOSS/100'
1	0.93	0.37	0.87	0.56	0.11	0.26	0.37	0.04	0.08	0.27	0.02	0.04	0.16	0.00	0.01
2	1.85	1.35	3.13	1.13	0.40	0.93	0.75	0.13	0.30	0.53	0.06	0.13	0.31	0.02	0.04
3	2.78	2.87	6.62	1.69	0.86	1.98	1.12	0.27	0.63	0.80	0.12	0.28	0.47	0.03	0.07
4	3.70	4.88	11.28	2.25	1.46	3.37	1.49	0.46	1.07	1.06	0.20	0.47	0.62	0.05	0.13
5	4.63	7.38	17.06	2.82	2.21	5.10	1.86	0.70	1.62	1.33	0.31	0.71	0.78	0.08	0.19
6	Greater than 5 FPS			3.38	3.09	7.15	2.24	0.98	2.27	1.60	0.43	1.00	0.93	0.12	0.27
7				3.95	4.12	9.51	2.61	1.31	3.02	1.86	0.58	1.33	1.09	0.15	0.36
8				4.51	5.27	12.17	2.98	1.68	3.87	2.13	0.74	1.71	1.24	0.20	0.46
9				Greater than 5 FPS			3.35	2.08	4.82	2.39	0.92	2.12	1.40	0.25	0.57
10							3.73	2.53	5.85	2.66	1.12	2.58	1.55	0.30	0.69
11							4.10	3.02	6.98	2.93	1.33	3.08	1.71	0.36	0.83
12							4.47	3.55	8.20	3.19	1.56	3.61	1.86	0.42	0.97
13							4.84	4.12	9.51	3.46	1.81	4.19	2.02	0.49	1.13
14							Greater than 5 FPS			3.72	2.08	4.81	2.17	0.56	1.29
16										4.26	2.67	6.16	2.48	0.72	1.65
18										4.79	3.32	7.66	2.79	0.89	2.06
20										Greater than 5 FPS			3.10	1.08	2.50
22													3.41	1.29	2.98
24													3.72	1.52	3.51
26													4.03	1.76	4.07
31													4.81	2.44	5.63
36													Greater than 5 FPS		
41															
46															

Table 11 Thrust Block; Design

Date

WV

THRUST BLOCK DESIGN

Fill In CLEAR CELLS

Field Office		Design By:		Date:	
Land Owner		Check By:		Date:	
County		Approved B		Date:	

Planned Practice and planned Installation (see attached plan)

Note: Maximum Allowed Pipe Pressure must be <72% of pipe pressure rating.

forces that make the pipeline move. Thrust blocks are masses of concrete used to transfer the thrust to the undisturbed soil in the trench and keep the pipeline from moving or breaking.

Thrust blocks shall be provided on pipelines having a working pressure of 25 psi or greater at change in pipeline grade, horizontal alignment or reduction in pipe size, at ends, tees, bends and inline control valves.

Area of concrete thrust block required in absence of manufacturer's recommendations, is in square feet

Dead ends and tees shall be 0.7 times block area for 90 deg. bends

$A=((98HD^2)/B \sin(a/2)$	example	
A= Area of Thrust Block Required (ft^2) -1' thick	1.30	
D= inside diameter of pipe (ft),	0.172	
B=Allowable passive pressure of the soil lb/ft2,	700	
a=deflection angle of pipe bend	90	
h= Pipe Pressure PSI	160.00	
H-1= Allowed Working Pressure of Pipe (psi) 72%	115.20	
H=Max. Allowed Working Pressure of Pipe (ft)	266.11	
Dead End or Tee= 0.7, other =1.0	1.00	

Depth of Cover to Center of Thrust Blocks (ft)	2	3	4
Natural Soil Material	Soil Properties lb/ft^2		
Sound Bedrock	8000	10000	10000
Dense sand (theta=40 deg.)	1200	1800	2400
Course sand (theta=35 deg.)	800	1200	1650
Silt and Clay (theta=25 deg.)	500	700	950
Soft Clay & Organic (theta=10 deg.)	200	300	400

Pipe Size	$A=ft^2$ x 1' thick	Pipe Inside Dia. Inches	Pipe outside Diameter inches	Working Pressure of Pipe psi	Allowed Working Pressure of Pipe (PSI)	B soil lb/ft2	a (angle of bend deg.)	Depth of pipe in feet	Dead End or Tee= 0.7, other =1.0	H-Allowable Working Pressure in Ft.	Depth of Pipe to CL	Pipe Inside Dia. Feet	Pipe outside Dia. Feet
2."SDR 26-160 psi-1120/1220	**1.30**	2.067	2.125	160	115.2	700	90	3	1.0	266.11	3.09	0.172	0.177
2."SDR 26-160 psi -dead end or tee	**1.00**	2.067	2.125	160	115.2	700	90	3	0.7	266.11	3.09	0.172	0.177
	#DIV/0!									0.00	0.00	0.000	0.000
	#DIV/0!									0.00	0.00	0.000	0.000
	#DIV/0!									0.00	0.00	0.000	0.000
	#DIV/0!									0.00	0.00	0.000	0.000
	#DIV/0!									0.00	0.00	0.000	0.000
	#DIV/0!									0.00	0.00	0.000	0.000

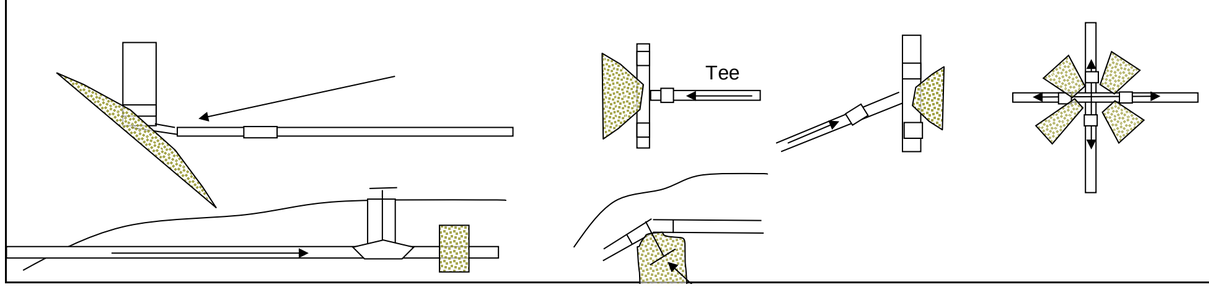


Table 11 Thrust Block; Design

Date

WV

THRUST BLOCK DESIGN

Fill In CLEAR CELLS

Field Office		Design By:		Date:
Land Owner		Check By:		Date:
County		Approved B		Date:

Planned Practice and planned Installation (see attached plan)

Note: Maximum Allowed Pipe Pressure must be <72% of pipe pressure rating.

forces that make the pipeline move. Thrust blocks are masses of concrete used to transfer the thrust to the undisturbed soil in the trench and keep the pipeline from moving or breaking.

Thrust blocks shall be provided on pipelines having a working pressure of 25 psi or greater at change in pipeline grade, horizontal alignment or reduction in pipe size, at ends, tees, bends and inline control valves.

Area of concrete thrust block required in absence of manufacturer's recommendations, is in square feet

Dead ends and tees shall be 0.7 times block area for 90 deg. bends

	example	
$A=((98HD^2)/B \sin(a/2)$		
A= Area of Thrust Block Required (ft^2) -1' thick	1.515575	
D= inside diameter of pipe (ft),	0.17225	
B=Allowable passive pressure of the soil lb/ft2,	600	
a=deflection angle of pipe bend	90	
h= Pipe Pressure PSI	160.00	
H-1= Allowed Working Pressure of Pipe (psi) 72%	115.20	
H=Max. Allowed Working Pressure of Pipe (ft)	266.11	

Depth of Cover to Center of Thrust Blocks (ft)	2	3	4
Natural Soil Material	Soil Properties lb/ft^2		
Sound Bedrock	8000	10000	10000
Dense sand (theta=40 deg.)	1200	1800	2400
Course sand (theta=35 deg.)	800	1200	1650
Silt and Clay (theta=25 deg.)	500	700	950
Soft Clay & Organic (theta=10 deg.)	200	300	400

Pipe Size and Specifications	$A=ft^2$ x 1' thick	Pipe Inside Dia. Inches	Pipe outside Diameter inches	Working Pressure of Pipe (PSI)	Allowed Working Pressure of Pipe (PSI)	B soil lb/ft2	a (angle of bend deg.)	Depth of pipe in feet	Dead End or Tee= 0.7, other =1.0	H-Allowable Working Pressure in Ft.	Depth of Pipe to CL	Pipe Inside Dia. Feet	Pipe outside Dia. Feet

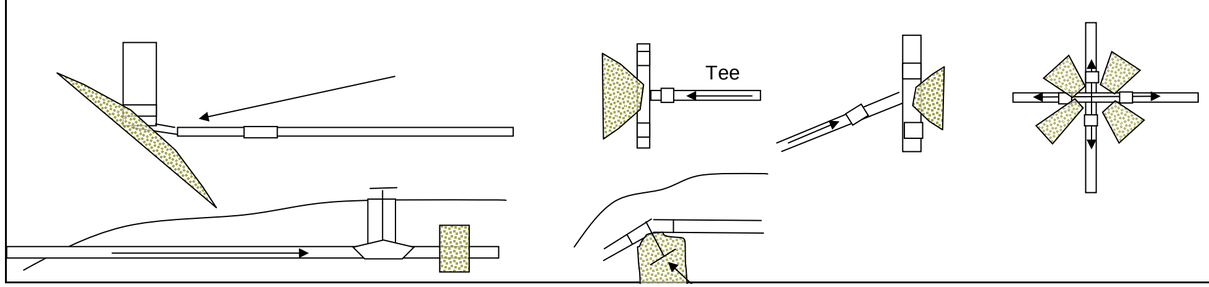
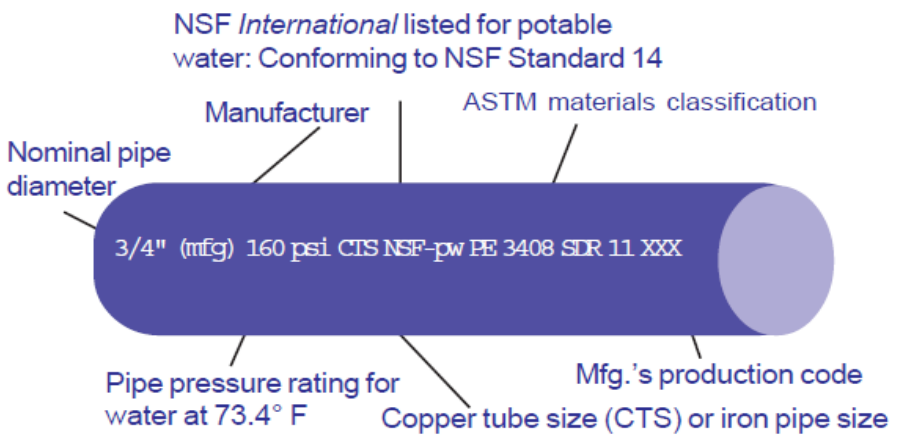


TABLE 12 Pipe Pressure Rating Tables

These are the most common plastic pipe materials used for pipelines or irrigation systems. Pressure classes are for unthreaded pipe only. Threaded pipe has a pressure classs lower than unthreaded pipe and is not recommended except where connection to nonplastic valves, fittings and devices re neededed.

PVC-SDR SERIES ASTM D 2241

SDR Rating	Design Class	Pipe Rating PSI	Allowable Working Press(72%)
17	250	180	129.6
21	200	144	103.68
26	160	115	82.8
32.5	125	90	64.8
41	100	72	51.84
51	80	58	41.76
81	50	36	25.92



PVC- SCHEDULE 40 (ASTM D 1785)

Nominal Pipe	PVC 1120, 1220, 2120 Pipe Rating PSI	Allowable Working Press(72%)
0.75	480	345.6
1	450	324
1.25	370	266.4
1.5	330	237.6
2	280	201.6
2.5	300	216

PVS- SCHEDULE 40 (ASTM D 1785)

Nominal Pipe S	PVC 2116 Pipe Rating PSI	Allowable Working Press(72%)
0.75	390	280.8
1	360	259.2
1.25	290	208.8
1.5	260	187.2
2	220	158.4
2.5	240	172.8

PVS- SCHEDULE 40 (ASTM D 1785)

Nominal Pip	PVC 2110 Pipe Rating PSI	Allowable Working Press(72%)
0.75	240	172.8
1	220	158.4
1.25	180	129.6
1.5	170	122.4
2	140	100.8
2.5	150	108

PVC- SCHEDULE 80 (ASTM D 1785)

Nominal Pipe	PVC 1120, 1220, 2120 Pipe Rating PSI	Allowable Working Press(72%)
0.75	690	496.8
1	630	453.6
1.25	520	374.4
1.5	470	338.4
2	400	288
2.5	420	302.4

PVC- SCHEDULE 80 (ASTM D 1785)

Nominal Pipe S	PVC 2116 Pipe Rating PSI	Allowable Working Press(72%)
0.75	550	396
1	500	360
1.25	420	302.4
1.5	380	273.6
2	320	230.4
2.5	340	244.8

PVC- SCHEDULE 80 (ASTM D 1785)

Nominal Pip	PVC 2110 Pipe Rating PSI	Allowable Working Press(72%)
0.75	430	309.6
1	390	280.8
1.25	320	230.4
1.5	290	208.8
2	250	180
2.5	260	187.2

PE- SCHEDULE 40 (ASTM D 2447)

Nominal Pipe	PE 2306, 2406, 3306, 3406 Pipe Rating PSI	Allowable Working Press(72%)
0.75	690	496.8
1	630	453.6
1.25	520	374.4
1.5	470	338.4
2	400	288
2.5	420	302.4

PE- SCHEDULE 40 (ASTM D 2447)

Nominal Pipe S	PE 2305 Pipe Rating PSI	Allowable Working Press(72%)
0.75	120	86.4
1	113	81.36
1.25	92	66.24
1.5	83	59.76
2	69	49.68
2.5	76	54.72

PE- SCHEDULE 40 (ASTM D 2447)

Nominal Pip	PE 1404 Pipe Rating PSI	Allowable Working Press(72%)
0.75	96	69.12
1	90	64.8
1.25	74	53.28
1.5	66	47.52
2	55	39.6
2.5	61	43.92

PE- Polyethylene (PE) SDR Pressure Rated Tube ASTM 2239

SDR	PE 2306, 3206,3069 Pipe Rating PSI	Allowable Working Press(72%)
7	200	144
9	160	115.2
11.5	125	90
15	100	72

TABLE 13 Pipe Pressure Rating Tables

PE- SCHEDULE 80 (ASTM D 2447)

Nominal Pipe	PE 2306, 2406, 3306, 3406 Pipe Rating PSI	Allowable Working Press(72%)
0.75	217	156.24
1	199	143.28
1.25	164	118.08
1.5	148	106.56
2	127	91.44
2.5	134	96.48

PE- SCHEDULE 80 (ASTM D 2447)

Nominal Pipe S	PE 2305 Pipe Rating PSI	Allowable Working Press(72%)
0.75	172	123.84
1	158	113.76
1.25	130	93.6
1.5	118	84.96
2	101	72.72
2.5	106	76.32

PE- SCHEDULE 80 (ASTM D 2447)

Nominal Pip	PE 1404 Pipe Rating PSI	Allowable Working Press(72%)
0.75	137	98.64
1	126	90.72
1.25	104	74.88
1.5	94	67.68
2	81	58.32
2.5	85	61.2

PE- DR Series (ASTM D 3035)

DR	PE 3408 Pipe Rating PSI	Allowable Working Press(72%)
13.5	128	92.16
17	100	72
21	80	57.6

PE- DR Series (ASTM D 3035)

DR	PE 2306, 2406, 3306, 3406 Pipe Rating PSI	Allowable Working Press(72%)
13.5	100	72
17	79	56.88
21	63	45.36

PE- DR Series (ASTM D 3035)

DR	PE 1404 Pipe Rating PSI	Allowable Working Press(72%)
13.5	64	46.08
17	50	36
21	40	28.8

ABS - SDR Series (ASTM D 2282)

DR	ABS 1316 Pipe Rating PSI	Allowable Working Press(72%)
13.5	250	180
17	200	144
21	160	115.2

ABS - SDR Series (ASTM D 2282)

DR	ABS 2112 Pipe Rating PSI	Allowable Working Press(72%)
13.5	200	144
17	160	115.2
21	125	90

ABS - SDR Series (ASTM D 2282)

DR	ABS 1210 Pipe Rating PSI	Allowable Working Press(72%)
13.5	160	115.2
17	125	90
21	100	72

ABS- SCHEDULE 40 (ASTM D 1527)

Nominal Pipe	ABS 1316 Pipe Rating PSI	Allowable Working Press(72%)
0.75	390	280.8
1	360	259.2
1.25	290	208.8
1.5	260	187.2
2	220	158.4
2.5	240	172.8

ABS- SCHEDULE 40 (ASTM D 1527)

Nominal Pipe S	ABS 2112 Pipe Rating PSI	Allowable Working Press(72%)
0.75	300	216
1	280	201.6
1.25	230	165.6
1.5	210	151.2
2	170	122.4
2.5	190	136.8

ABS- SCHEDULE 40 (ASTM D 1527)

Nominal Pip	ABS 1210 Pipe Rating PSI	Allowable Working Press(72%)
0.75	240	172.8
1	220	158.4
1.25	180	129.6
1.5	170	122.4
2	140	100.8
2.5	150	108

ABS- SCHEDULE 80 (ASTM D 1527)

Nominal Pipe	ABS 1316 Pipe Rating PSI	Allowable Working Press(72%)
0.75	550	396
1	500	360
1.25	420	302.4
1.5	380	273.6
2	320	230.4
2.5	340	244.8

ABS- SCHEDULE 80 (ASTM D 1527)

Nominal Pipe S	ABS 2112 Pipe Rating PSI	Allowable Working Press(72%)
0.75	430	309.6
1	390	280.8
1.25	330	237.6
1.5	290	208.8
2	250	180
2.5	270	194.4

ABS- SCHEDULE 80 (ASTM D 1527)

Nominal Pip	ABS 1210 Pipe Rating PSI	Allowable Working Press(72%)
0.75	340	244.8
1	320	230.4
1.25	260	187.2
1.5	240	172.8
2	200	144
2.5	210	151.2

Table 13-TYPICAL FRICTION FITTING LOSSES

Effect of friction associated with	Equivalent Pipe Length												
Inside pipe Diameter	0.5	0.75	1	1.25	1.5	2	2.5	3	3.5	5	4	5	6
Type of Fitting													
90 deg. Elbow	1.5	2.2	2.7	3.7	4.3	5.5	6.5	8.1					
45 deg. elbow	0.77	1	1.3	1.6	2	2.5	3	3.8	4.4	6.1	5	5.6	6.1
tee	3.4	4.5	5.8	7.8	9	11	14	17	19	27	22	24	27
return bend	3.8	5	6.1	8.5	10	13	15	18	21	31	24	27	31
Gate valve, wide open	0.35	0.47	0.6	0.8	0.95	1.2	1.4	1.7	2	2.9	2.3	2.6	2.9
Globe Valve	16	22	27	37	44	57	66	85	99	140	110	130	140
Angle valve Open	8.4	12	15	18	22	28	33	42	50	70	58	61	70
Sudden Entrance	1.4	1.8	2.3	3	3.6	4.6	5.4	6.8	8	12	9.1	10	12
Chemigation valve	0.35	0.47	0.6	0.8	0.95	1.2	1.4	1.7	2	2.9	2.3	2.6	2.9
Typ. Water Hydrant (including Stem)		25.4	29.8										

13a-Head Loss Coefficients for Fitts and Special Condiitions where $H=KV^2/2g$

Nature of Resistance	Typical Value -K	Remarks
Check Valve	,3.0-10	
Elbow		
90 deg	0.4	
45 deg.	0.65	
Entrance		
Square	0.5	
Projecting	0.78	
Rounded	0.05	
Gate Valve Open	0.25	
Globe Valve Open	6	
Sudden Contraction	0.4	V= velocity of smaller pipe
Sudden Enlargement	$1-(d_1^2/d_2^{2)}$	d_1 (small pipe) and d_2 (large pipe)
Taper Reducer	0.25	V= velocity of smaller pipe
Taper Increaser	0.15	V= velocity of smaller pipe
Tees or Crosses		
Straight Flow	0.1	
Angle Flow	1.5	
Angle Valve	5	

13b- "C" Factor in Hazen-Williams Equation for Full Pipe Flow

hf = 10.536 x ((Q^ 1.852)/(C^1.852)) x (D^-4.871) x L(ft)

C-Type of Pipe	Range	New Pipe	Design C
PVC	160-145	150	150
POLETHYLENE	150-130	140	140
WELDED STEEL	150-80	140	140
RIVETED STEEL	140-90	110	110
CONCRETE	150-85	120	120
CAST IRON	150-80	130	130
COPPER BRASS	150-120	140	140
WOOD STAVE	145-110	120	120
CITRIFIED CLAY		110	110
CORRUGATED STEEL		60	60

For Plastic Pipe
Use C=130 when pipe is lessor = to 1"
Use C=140 when pipe is less than= 3" and >1"
Use C=150 or lessor value in table when >3"

CHART II
EQUIVALENT LENGTHS OF PIPE

n = 0.009	DIAMETER						
	1/2	3/4	1	1 1/4	1 1/2	2	3
90° ELBOW (STANDARD)	0.6	1.0	1.4	2.0	2.5	3.7	6.3
45° ELBOW (STANDARD)	0.4	0.6	1.0	1.3	1.7	2.4	4.2
GATE VALVE (OPEN)	0.2	0.4	0.6	0.8	1.0	1.5	2.6
CONTRACTION ($\frac{d_1}{d_2}$ = 1.5)	0.2	0.3	0.5	0.7	0.9	1.3	2.2

Mannings Formula: $Q = \frac{0.276}{n} d^{8/3} s^{1/2}$

Q = Quantity of Flow in Gal./Min.

d = Diameter of Pipe in Inches

n = Coefficient of Roughness of Pipe

s = Hydraulic Gradient in Ft./Ft = hf/l

Values for C for different types of pipe are given in Table 3-2.

Regardless of the designer's preference of equations, the results should be checked against the application of State design criteria.

Table 3-1 Values of Manning's, n

Description of pipe	Values of n Min.	Design	Max.
Cast-iron, coated	0.010	0.012 - 0.014	0.014
Cast-iron, uncoated	0.011	0.013 - 0.015	0.015
Wrought iron, galvanized	0.013	0.015 - 0.017	0.017
Wrought iron, black	0.012		0.015
Steel, riveted and spiral	0.013	0.015 - 0.017	0.017
Annular corrugated metal	0.021	0.021 - 0.025	0.0255
Helical corrugated metal	0.013	0.015 - 0.020	0.021
Wood stave	0.010	0.012 - 0.013	0.014
Neat cement surface	0.010		0.013
Concrete	0.010	0.012 - 0.017	0.017
Vitrified sewer pipe	0.010	0.013 - 0.015	0.017
Clay, common drainage tile	0.011	0.012 - 0.014	0.017
Corrugated plastic	0.014	0.015 - 0.016	0.017

Table 3-2 Values of Hazen-Williams C

Description of pipe	C
Very smooth pipe; straight alignment	140
Very smooth pipe; slight curvature	130
Cast iron, uncoated - new	130
5 years old	120
10 years old	110
15 years old	100
20 years old	90
30 years old	80
coated - all ages	130
Steel pipe, welded, new	130
(Same deterioration with age as cast iron, uncoated)	
For permanent installation use	100
Wrought iron or standard galvanized steel - dia. 12-in. up	110
4 to 12 in.	100
4 in. down	80
Brass or lead, new	140
Concrete, very smooth, excellent joints	140
smooth, good joints	120
rough	110
Vitrified	110
Smooth wooden or wood stave	120
Asbestos cement	140
Corrugated pipe	60

Note: Pipes of small diameter, old age, and very rough inside surface, may give values as low as C = 40

EFM Notice-3, 10/21/70

Handbook of PVC Pipe, 4th Edition, 2001
Table 9.1

$$Hf\ (FT) = \frac{10.536}{C^{1.852}} \times \frac{Q(GPM)^{1.852}}{D(I.D.\ In.)^{4.871}} \times L\ (ft)$$

C-Type of Pipe	Range	New Pipe	Design C
PVC	160-145	150	150
POLETHYLENE	150-130	140	140
WELDED STEEL	150-80	140	140
RIVETED STEEL	140-90	110	110
CONCRETE	150-85	120	120
CAST IRON	150-80	130	130
COPPER BRASS	150-120	140	140
WOOD STAVE	145-110	120	120
CITRIFIED CLAY		110	110
CORRUGATED STEEL		60	60

Use C=130 when pipe is lessor = to 1"
Use C=140 when pipe is less than= 3" and >1"
Use C=values in table when >3"

Table 14

Table 6–7 Friction loss in flexible irrigation hose used on traveling gun type sprinkle system

Flow (gpm)	Friction Loss (lb/in²/100 ft) hose size (in) 2 1/2	3	3 1/2	4	4 1/2	5
	lb/in² per 100 ft					
100	1.6	0.7	0.3			
150	3.4	1.4				
200	5.6	2.5	1.4	0.6		
250		3.6		0.9		
300		5.1	2.6	1.3	0.6	
400			2.3	1.3		
500			3.5	2.1		
600				4.9	2.7	1.1
700				3.6	2.1	
800					4.6	2.7
900						3.4
1000						4.2

Table 6–8 Guidelines for sizing traveling gun type sprinkler hoses

Flow range (gpm)	Hose diameter (in)
50 to 150	2.5
150 to 250	3.0
200 to 350	3.5
250 to 500	4.0
500 to 700	4.5
> 700	5.0

Table 15 Pipeline Material Water Hammer or Surge Pressure

A water hammer or surge pressure occurs when the flow velocity in a pipe system is suddenly stopped or changed. The mass of the inertia of the water is converted into a pressure wave or high static head on the pressure side of the pipeline. Most causes of a water hammer are the opening and closing of valves, starting and stopping pumps, entrapped air, and poor pipe system layout. Calculating Surge Pressure is important in areas where either a high flow or elevation (>50') changes occur and there is a valve with an instaneous stop. Excessive pressures can build up and the allowable PSI on a pipe should be evaluated. Based on NEH Part 636 - Chapter 52- Structural Design of Flexible Conduits

Yellow-computer entered number, green - calculated funtion, blank- enter hand written number or calculation

1- Determne the Pressure Wave Velocity for water

$$a_{w=} \quad \frac{4720}{(1+((K_L (SDR-2)/E)))^{0.5}}$$

a_w wave velocity (FPS)

K_L fluid bulk modulus, 300,000 psi for water

SDR Standard Dimension Ratio for the pipe = Outside Diameter/ pipe thickness

E Modulus of elasticity of the pipe, PSI

E= 29,000,000 for Steel Pipe

E- 400,000 for PVC (short term)

E= 300,000 for ABS pipe (short term)

E= 110,000 for Polyethylene (short term)

a_w (FPS)	K_L	SDR	E	
1082.84	300000	26	400000	Example- PVC,SDR26, 160 PSI, 1.0" dia., 10 GPM

Table 9-UNIT SURGE PRESSURE FOR PVC AND

PVC PIPE PRESSURE SURGE*		PE 3408 PRESSURE SURGE	
Dimensio Ratio	psi/fps*	Dimension Ratio	psi/fps*
13.5	20.2	7.3	16.3
14	19.8	9	14.3
17	17.9	9.3	14
18	17.4	11	12.7
21	16	13.5	11.3
25	14.7	17	9.9
26	14.4	21	8.8
32.5	12.8	26	7.9
41	11.4	32.5	7

* Change in V= 1 FPS

2- Determine the surge pressure from a water hammer is equal to H surge = (a x (Vc)/g Velocity (Vc) at valve, Vc= V1-V2, V1= velocity at start, V2 velociaty at stop, g=32.2 ft^2/s

2a. What is the maximum Q (GPM) in (FPS)?
Convert Q(GPM) to q (FPS)
q (FPS) = Q (GPM) /448.8

Q (GPM)	Q (FPS) =	
10	0.0223	example

2b. Determine the cross-sectional area of the pipe in (SF)
$P_{A=}$ pi x r^2

P_A (SF) =	Inside Diameter (in)	radius (ft)	
0.00779	1.195	0.050	example

2 c. Calculate the Change in Velocity
V= Q(CFS).A(SF)

Vc =	CFS	Area (SF)	
2.861	0.022	0.008	example

3-Caluclate the Surge Pressure
$P_s = a_w * Vc/2.31\ g \quad g = 32.2\ F/S^2$

P_s (PSI)	a_w (FPS)	Vc (FPS)	g(F/Sec^2)	
41.65	1082.84	2.861	32.2	example

4-. Is the Allowable Pipe Pressure greater than the Pipe Surge Pressure (Ps)?

Pipe Pressure Rating (PSI)	Allowable Working Pressure (PSI)	P_s (PSI)		
160	115.2	41.65	OK	example

WV ENG 430 C PIPELINE FRICTION COMPUTATIONS			Fill in Blank Data Blocks, Green are Computer Generated, Grey are Information	
			Name	Date
Field Office	Example FO	Design By	ex	3/3/2011
Land Owner	Example Owner	Check By	am2	3/13/2011
County	Example County	Approved By	ple3	3/18/2011

Note: Pump Discharge must be <72% of pipe pressure rating.	Pump Can Deliver GPM According to Well Driller Report or Test	80	GPM	Available water for Irrigation	64	GPM	

Use Table WVENG 430-516 Typical Pipe Friction Losses to determine Pipeline friction loss, the Hazen Williams Equation or other suitable tables.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), C is the pipe factor friction factor (Hazen Williams C (Part 623 Irrigation, Chapter 7, Table 7-23) Factor- Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" and Table 13b), D= ID of pipe (inches), L= pipe length (ft).
hf = 10.536 x ((Q^ 1.852)/(C^1.852)) x (D^-4.871) x L(ft)

Evaluation is from the Water Well draw down surface (Below Ground) to the Pressure Tank

1. Determine the Elevation Head =vertical feet from the Pump's Water Surface to the pressure tank.

	Ground at Well	Water Below Ground	Draw Down (ft)	Assumed Water Level Elev.	Pressure Tank	Elevation Head (feet)
Elevation	49	-19	-20	10	51	41

NOTE: 1-TYPCIAL PRESSURE REQUIREMENTS FOR NON-PIPELINE APPURTENANCES ARE FOR PRESSURE TANKS (30-50 OR 40-60 PSI), CYCLE STOP VALVES (20-40 PSI), FULL FLOW FLOAT VALVES (5-7 PSI), AUTOMATIC WATERING SYSTEMS (15 SPI), MICROIRRIGATION IRRIGATON (8 OR 10 PSI), SOLID SET SPRINKLER IRRIGAITON (20-50 PSI), SAND FILTERS (10 PSI), DISC FILTERS (2 PSI) 2- MAXIMUM VELOCITY ON PIPELINE IS 5 FT.PER sect, 3.

2. Determine the Friction Head using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees Fahrenheit.

Well Pipe	Main	Sub-Main	Header or Other	GPM	C Factor	Pipe Dia.	Pipe Material	ID Dia.(in.)	V ft/sec^2	Pipeline Length (ft)	Pipe Friction Loss (ft./100')	Fitting Type	No. of Fittings	Fitting Loss Equivalent Length (ft)	Hf Friction Loss Evaluation Length	Pipeline Friction Head (Hf) (Ft)	NOTES
LINER				10	100	1.5	steel		<5	8	0.0145	Type of Fitting	0	0	8	0.12	
FITTINGS				10	100	1.5	steel		<5	0	0.0145	90 deg. Elbow	4	4.3	17.2	0.25	
PITLESS ADAPTER				10	100	2	steel		<5	0	0.0145	Angle valve Open	1	22	22	0.32	
TO PRESSURE TANK	1			10	130	1	SCH 40 PVC	1.05	3.83	2	0.0313	Type of Fitting	0	0	2	0.06	
						1						Type of Fitting			0	0.00	
2. FRICTION HEAD															SUM (Hf)	0.75	

3. PRESSURE HEAD FOR WATER TANK	30	PSI Low Pressure	50	PSI High Pressure	115.5	
3a. CYCLE STOP VALVES (TYP 20-50 PSI)	20	PSI Low Pressure	40	PSI High Pressure	92.4	
4. ELEVATION HEAD FROM WL TO PRESSURE TANK					41.0	
5. EST. APPROXIMATE BRAKE HORSEPOWER	65	% Eff.	= TDH(FT) X Q (GPM)/(3960 X EFF %/100) =	0.97 HP Attach Pump Curve	248.90	DYANAMIC HEAD TO PRESSURE TANK (FT)
6. VERIFY PRESSURE TANK WILL MEET IRRIGATION REQUIREMENTS		55.1	ft = IRR HEAD	248.90 ft = HEAD TO PRESSURE TANK	**OK**	

MAIN, SUB-MAIN, HEADER AND MICROIRRIGAION SYSTEM

Note: This evaluation is from the PRESSURE TANK to the MICROIRRIGATION

Pipe flow using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees Fahrenheit.

Main	Sub-Main	Header or Other	GPM	C	Pipe Dia.	Pipe Material	ID Dia.(in.)	V ft/sec 2	Pipeline Length (ft)	Pipe Friction Loss (ft./100')	Fitting Type	No. of Fittings	Fitting Loss Equivalent Length (ft)	Hf Friction Loss Evaluation Length	Pipeline Friction Loss (ft)	Start Elevation	End Elevation	He -Elevation Loss (+ uphill, - downhill) Ft.	Hf + He (ft)	PSI	SUM PSI	Notes
	1		4	130	1	Sch 40 PVC	1.049	1.53	430	0.0132	90 deg. Elbow	2	2.7	435.4	0.10	49	104	55	55.1	24	24	
	1		4	130	1	Sch 40 PVC	1.049	1.5	0	0.0132	45 deg. elbow	4	1.3	5.2	0.00	104	104	0	0.0	0	24	
	1		4	130	1	Sch 40 PVC	1.049	1.5	0	0.0132	tee	4	0.6	5.8	0.00	104	104	0	0.0	0	24	
		1	4	130	1	PE Blue Line Pipe	0.613	2.5	30	0.0458	Gate valve, wide open	1	0.6	30.6	0.00	104	101	-3	-3.0	-1	23	
		1	4	130	0.75	PE Blue Line Pipe	0.613	2.5	30	0.0458	tee	4	4.5	48	0.00	104	101	-3	-3.0	-1	21	
		1	2	130	0.75	PE Blue Line Pipe	0.613	2.5	30	0.0458	tee	4	4.5	48	0.00	100	98	-2	-2.0	-1	20	
											Type of Fitting							0	0.0	0	20	
											Type of Fitting							0	0.0	0	20	
															0.10						24	Maximum PSI

Pressure required at emitter or Float Valve	10	Aqua-Traxx Pressure Requirement
Miscellaneous Filters (sand 8 psi, disc, 5 psi, etc.)	5	Aqua-Traxx Pressure Requirement
	FT	Max PSI
MAXIMUM ELEVATION AND FRICTION HEAD FROM TANK TO SYSTEM	55.1	24

OK, 30-50 PSI Pressure Tank can deliver this to sprinkler.

Effect of friction associated with pipe	Equivalent Pipe Length												
Pipe Diameter	0.5	0.75	1	1.25	1.5	2	2.5	3	3.5	5	4	5	6
Type of Fitting													
90 deg. Elbow	1.5	2.2	2.7	3.7	4.3	5.5	6.5	8.1					
45 deg. elbow	0.77	1	1.3	1.6	2	2.5	3	3.8	4.4	6.1	5	5.6	6.1
tee	3.4	4.5	5.8	7.8	9	11	14	17	19	27	22	24	27
return bend	3.8	5	6.1	8.5	10	13	15	18	21	31	24	27	31
Gate valve, wide open	0.35	0.47	0.6	0.8	0.95	1.2	1.4	1.7	2	2.9	2.3	2.6	2.9
Globe Valve	16	22	27	37	44	57	66	85	99	140	110	130	140
Angle valve Open	8.4	12	15	18	22	28	33	42	50	70	58	61	70
Sudden Entrance	1.4	1.8	2.3	3	3.6	4.6	5.4	6.8	8	12	9.1	10	12
Chemigation valve	0.35	0.47	0.6	0.8	0.95	1.2	1.4	1.7	2	2.9	2.3	2.6	2.9
Typ. Water Hydrant (Including Stem)		25.4	29.8										
Other													

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Table 9.1

Hf (FT) = 10.536 x Q(GPM)^1.852 x L (ft)

C^1.852 x D(I.D. In.)^4.871

C-Type of Pipe	Range	New Pipe	Design C	For Plastic Pipe
PVC	160-145	150	150	Use C=130 when pipe is lessor = to 1"
POLETHYLENE	150-130	140	140	Use C=140 when pipe is less than= 3" and >1"
WELDED STEEL	150-80	140	140	Use C=150 or lessor value in table when >3"
RIVETED STEEL	140-90	110	110	
CONCRETE	150-85	120	120	
CAST IRON	150-80	130	130	
COPPER BRASS	150-120	140	140	
WOOD STAVE	145-110	120	120	

WV ENG 430 C PIPELINE FRICTION COMPUTATIONS			Fill in Blank Data Blocks, Green are Computer Generated, Grey are	
			Name	Date
Field Office		Design By		
Land Owner		Check By		
County		Approved By		

Note: Pump Discharge must be <72% of pipe pressure rating.	Pump Can Deliver GPM According to Well Driller Report or Test	80	GPM	Available water for Irrigation	64	GPM

Use Table WVENG 430-516 Typical Pipe Friction Losses to determine Pipeline friction loss, the Hazen Williams Equation or other suitable tables.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), C is the pipe factor friction factor (Hazen Williams C (Part 623 Irrigation, Chapter 7, Table 7-23) Factor- Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" and Table 13b), D= ID of pipe (inches), L= pipe length (ft).
hf = 10.536 x ((Q^ 1.852)/(C^1.852)) x (D^-4.871) x L(ft)

Evaluation is from the Water Well draw down surface (Below Ground) to the Pressure Tank

1. Determine the Elevation Head =vertical feet from the Pump's Water Surface to the pressure tank.

	Ground at Well	Water Below Ground	Draw Down (ft)	Assumed Water Level Elev.	Pressure Tank	Elevation Head (feet)
Elevation						

NOTE: 1-TYPCIAL PRESSURE REQUIREMENTS FOR NON-PIPELINE APPURTENANCES ARE FOR PRESSURE TANKS (30-50 OR 40-60 PSI), CYCLE STOP VALVES (20-40 PSI), FULL FLOW FLOAT VALVES (5-7 PSI), AUTOMATIC WATERING SYSTEMS (15 SPI), MICROIRRIGATION IRRIGATON (8 OR 10 PSI), SOLID SET SPRINKLER IRRIGAITON (20-50 PSI), SAND FILTERS (10 PSI), DISC FILTERS (2 PSI) 2- MAXIMUM VELOCITY ON PIPELINE IS 5 FT.PER sect, 3.

2. Determine the Friction Head using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees Fahrenheit.

Well Pipe	Main	Sub-Main	Header or Other	GPM	C Factor	Pipe Dia.	Pipe Material	ID Dia.(in.)	V ft/sec^2	Pipeline Length (ft)	Pipe Friction Loss (ft./100')	Fitting Type	No. of Fittings	Fitting Loss Equivalent Length (ft)	Hf Friction Loss Evaluation Length	Pipeline Friction Head (Hf) (Ft)	NOTES
LINER																	
FITTINGS																	
PITLESS ADAPTER																	
TO PRESSURE TANK																	

2. FRICTION HEAD						SUM (Hf)	
3. PRESSURE HEAD FOR WATER TANK		PSI Low Pressure		PSI High Pressure			
3a. CYCLE STOP VALVES (TYP 20-50 PSI)		PSI Low Pressure		PSI High Pressure			
4. ELEVATION HEAD FROM WL TO PRESSURE TANK							
5. EST. APPROXIMATE BRAKE HORSEPOWER		% Eff.	= TDH(FT) X Q (GPM)/(3960 X EFF %/100) =		HP	Attach Pump Curve	DYANAMIC HEAD TO PRESSURE TANK (FT)
6. VERIFY PRESSURE TANK WILL MEET IRRIGATION REQUIREMENTS			FT = IRR HEAD		FT = HEAD TO PRESSURE TANK		

MAIN, SUB-MAIN, HEADER AND MICROIRRIGAION SYSTEM

Note: This evaluation is from the PRESSURE TANK to the

Pipe flow using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees Fahrenheit.

Main	Sub-Main	Header or Other	GPM	C	Pipe Dia.	Pipe Material	ID Dia.(in.)	V ft/sec 2	Pipeline Length (ft)	Pipe Friction Loss (ft./100')	Fitting Type	No. of Fittings	Fitting Loss Equivalent Length (ft)	Hf Friction Loss Evaluation Length	Pipeline Friction Loss (ft)	Start Elevation	End Elevation	He -Elevation Loss (+ uphill, - downhill) Ft.	Hf + He (ft)	PSI	SUM PSI	Notes
																						Maximum PSI
Pressure required at emitter or Float Valve																						Aqua-Traxx Pressure
Miscellaneous Filters (sand 8 psi, disc, 5 psi, etc.)																						Pressure Requirement
																				FT	Max PSI	
															MAXIMUM ELEVATION AND FRICTION HEAD FROM TANK TO SYSTEM							Pressure Tank can deliver this to sprinkler.

WV ENG 430 C PIPELINE FRICTION COMPUTATIONS

Fill in Blank Data Blocks, Green are Computer Generated, Grey are Information

			Name	Date
Field Office		Design By		
Land Owner		Check By		
County		Approved By		

Note: Pump Discharge must be <72% of pipe pressure rating.

Pump Can Deliver GPM According to Well Driller Report or Test | | GPM | Available water for Irrigation | 0 | GPM

Use Table WVENG 430-516 Typical Pipe Friction Losses to determine Pipeline friction loss, the Hazen Williams Equation or other suitable tables.
Hazen Williams equation where; hf is the friction loss calculated in ft per 100 ft of pipe, Q is the flow measured in (GPM), C is the pipe factor friction factor (Hazen Williams C (Part 623 Irrigation, Chapter 7, Table 7-23) Factor- Plastic Pipe; C=130<= 1", C=140 <3"; C=150>=3" and Table 13b), D= ID of pipe (inches), L= pipe length (ft).
hf = 10.536 x ((Q^ 1.852)/(C^1.852)) x (D^-4.871) x L(ft)

Evaluation is from the Water Well draw down surface (Below Ground) to the Pressure Tank

1. Determine the Elevation Head =vertical feet from the Pump's Water Surface to the pressure tank.

	Ground at Well	Water Below Ground	Draw Down (ft)	Assumed Water Level Elev.	Pressure Tank	Elevation Head (feet)
Elevation						0

NOTE: 1-TYPCIAL PRESSURE REQUIREMENTS FOR NON-PIPELINE APPURTENANCES ARE FOR PRESSURE TANKS (30-50 OR 40-60 PSI), CYCLE STOP VALVES (20-40 PSI), FULL FLOW FLOAT VALVES (5-7 PSI), AUTOMATIC WATERING SYSTEMS (15 SPI), MICROIRRIGATION IRRIGATON (8 OR 10 PSI), SOLID SET SPRINKLER IRRIGAITON (20-50 PSI), SAND FILTERS (10 PSI), DISC FILTERS (2 PSI) 2- MAXIMUM VELOCITY ON PIPELINE IS 5 FT.PER sect, 3.

2. Determine the Friction Head using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees Fahrenheit.

Well Pipe	Main	Sub-Main	Header or Other	GPM	C Factor	Pipe Dia.	Pipe Material	ID Dia.(in.)	V ft/sec^2	Pipeline Length (ft)	Pipe Friction Loss (ft./100')	Fitting Type	No. of Fittings	Fitting Loss Equivalent Length (ft)	Hf Friction Loss Evaluation Length	Pipeline Friction Head (Hf) (Ft)	NOTES
LINER						1.5						Type of Fitting			0	0.00	
FITTINGS						1.5						90 deg. Elbow			0	0.00	
PITLESS ADAPTER						2						Angle valve Open			0	0.00	
TO PRESSURE TANK						1						Type of Fitting			0	0.00	
						1						Type of Fitting			0	0.00	

2. FRICTION HEAD					SUM (Hf)	0.00
3. PRESSURE HEAD FOR WATER TANK		PSI Low Pressure		PSI High Pressure		0.0
3a. CYCLE STOP VALVES (TYP 20-50 PSI)		PSI Low Pressure		PSI High Pressure		0.0
4. ELEVATION HEAD FROM WL TO PRESSURE TANK						0.0
5. EST. APPROXIMATE BRAKE HORSEPOWER		% Eff.	= TDH(FT) X Q (GPM)/(3960 X EFF %/100) =		HP Attach Pump Curve	0.00 DYANAMIC HEAD TO PRESSURE TANK (FT)
6. VERIFY PRESSURE TANK WILL MEET IRRIGATION REQUIREMENTS			FT = IRR HEAD	0.00	FT = HEAD TO PRESSURE TANK	**OK**

MAIN, SUB-MAIN, HEADER AND MICROIRRIGAION SYSTEM

Note: This evaluation is from the PRESSURE TANK to the

Pipe flow using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees Fahrenheit.

Main	Sub-Main	Header or Other	GPM	C	Pipe Dia.	Pipe Material	ID Dia.(in.)	V ft/sec 2	Pipeline Length (ft)	Pipe Friction Loss (ft./100')	Fitting Type	No. of Fittings	Fitting Loss Equivalent Length (ft)	Hf Friction Loss Evaluation Length	Pipeline Friction Loss (ft)	Start Elevation	End Elevation	He -Elevation Loss (+ uphill, - downhill) Ft.	Hf + He (ft)	PSI	SUM PSI	Notes
					0.75						90 deg. Elbow	2	2.7	5.4	0.00			0	0.0	0	0	
					1						45 deg. elbow	4	1.3	5.2	0.00			0	0.0	0	0	
					1						tee	1	5.8	5.8	0.00			0	0.0	0	0	
					0.75						tee	4	4.5	18	0.00			0	0.0	0	0	
					0.75						tee	4	4.5	18	0.00			0	0.0	0	0	
																		0	0.0	0	0	
																		0	0.0	0	0	
																		0	0.0	0	0	
															0.00						0	Maximum PSI
Pressure required at emitter or Float Valve																						Aqua-Traxx Pressure
Miscellaneous Filters (sand 8 psi, disc, 5 psi, etc.)																						Pressure Requirement
																				FT	Max PSI	
															MAXIMUM ELEVATION AND FRICTION HEAD FROM TANK TO SYSTEM					0	0	Pressure Tank can deliver this to sprinkler.

Pipe flow enegy estimation using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees

WV IRRIGATION General Information data sheet			Name	Date
Field Office		Design By		
Land Owner		Check By		
County		Approved By		

Note: Pump Discharge must be <72% of pipe pressure rating.

Fill in Yellow Data Blocks

Pipe flow using the Hazen Williams Equation, friction head losses in feet per foot of pipe length for fresh water at 50 degrees Fahrenheit.

Main	Sub-Main	Header or Other	GPM	C	Pipe Dia.	Pipe Material	ID Dia.(in.)	V ft/sec^2	Pipeline Length (ft)	Pipe Friction Loss (ft./100')	Fitting Type	No. of Fittings	Fitting Loss Equivalent Length (ft)	Hf Friction Loss Evaluation Length	Pipeline Friction Loss (ft)	Start Elevation	End Elevation	He - Elevation Loss (+ uphill, - downhill) Ft.	Hf + He (ft)	PSI	Notes:Mainlines Irrigation Lines From Pump Tank 2- Main Irrigatio line C to Existing Flower Gardens and Green houses
A			2	130	1.25	HDPE-SIDR15	2.067	0.2	770	0.1	90 deg. Elb	3	3.7	781.1	0.80	1760	1856	96	96.8	42	Above Ground
	a		2	130	1.25	HDPE-SIDR15	2.067	0.2	0	0.1	Gate valve	2	4.5	9	0.00	1856	1864	8	8.0	3	Check Valve and Gate Valve
			2	130	2	HDPE-SIDR15	2.067	0.2	140	0.1	90 deg. Elb	2	21.2	182.4	0.20	1883	1872	-11	-10.8	-5	Hydrant
			2	130	2	HDPE-SIDR15	2.067	0.2	0	0.1	90 deg. Elb	0	0	0	0.00	0	0	0	0.0	0	
			0	130	2	HDPE-SIDR15	2.067	0	0	0	90 deg. Elb	0	0	0	0.00	0	0	0	0.0	0	
			0	130	1	None	1.61	0	0	0	90 deg. Elb	0	0	0	0.00	0	0	0	0.0	0	
			0	130	0.75	None	1.61	0	0	0	90 deg. Elb	0	0	0	0.00	0	0	0	0.0	0	
			0	130	0.75	None	1.61	0	0	0	90 deg. Elb	0	0	0	0.00	0	0	0	0.0	0	
Static Water Depth to Start Elev.																1761	1761	0	0.0	0	
Miscellaneous Filters (sand 8 psi, disc 5 psi, hydrant 2 P																				0	Hyrdrant and Disc Filter
																		Total Head	94.0	41	
																			FT	PSI	
Pressure required for emitter, float valve																				40	
																				81	Min. Pressure at Pump
																				186.4	Min. Head (FT)
																				2	Gallons at Pump

Effect of friction associated	Equivalent Pipe Length												
Inside pipe Diameter	0.5	0.75	1	1.25	1.5	2	2.5	3	3.5	5	4	5	6
Type of Fitting													
90 deg. Elbow	1.5	2.2	2.7	3.7	4.3	5.5	6.5	8.1					
45 deg. elbow	0.77	1	1.3	1.6	2	2.5	3	3.8	4.4	6.1	5	5.6	6.1
tee	3.4	4.5	5.8	7.8	9	11	14	17	19	27	22	24	27
return bend	3.8	5	6.1	8.5	10	13	15	18	21	31	24	27	31
Gate valve, wide open	0.35	0.47	0.06	0.8	0.95	1.2	1.4	1.7	2	2.9	2.3	2.6	2.9
Globe Valve	16	22	27	37	44	57	66	85	99	140	110	130	140
Angle valve Open	8.4	12	15	18	22	28	33	42	50	70	58	61	70
Sudden Entrance	1.4	1.8	2.3	3	3.6	4.6	5.4	6.8	8	12	9.1	10	12
Chemigation valve	0.35	0.47	0.6	0.8	0.95	1.2	1.4	1.7	2	2.9	2.3	2.6	2.9
Typ. Water Hydrant (Including Stem)		25.4	29.8										

Handbook of PVC Pipe, 4th Edition, 2001

Table 9.1

$$Hf\ (FT) = \frac{10.536}{C^{1.852}} \times \frac{Q(GPM)^{1.852}}{D(I.D.\ In.)^{4.871}} \times L\ (ft)$$

C-Type of Pipe	Range	New Pipe	Design C	For Plastic Pipe
PVC	160-145	150	150	Use C=130 when pipe is lessor = to 1"
POLETHYLENE	150-130	140	140	Use C=140 when pipe is less than= 3" and >1"
WELDED STEEL	150-80	140	140	Use C=150 or lessor value in table when >3"
RIVETED STEEL	140-90	110	110	
CONCRETE	150-85	120	120	
CAST IRON	150-80	130	130	
COPPER BRASS	150-120	140	140	
WOOD STAVE	145-110	120	120	
CITRIFIED CLAY		110	110	
CORRUGATED STEEL		60	60	