Washtenaw County

Department of Planning & Environment
Development Services Division

DESIGN PROCEDURES AND ENGINEERING STANDARDS FOR PRESSURE DISTRIBUTION NETWORKS

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Introduction

A pressure distribution network (PDN) applies effluent uniformly over the entire absorption area such that it provides a specific volume of effluent to a specific area with each dosing cycle at a rate less than the saturated hydraulic conductivity of the soil. This process should promote soil treatment capabilities by application of uniform distribution and more effectively maintaining unsaturated conditions in the soils media.

Suggested Use and Potential Benefits

Pressure distribution is applicable to any system where uniform application of sewage effluent is sought. It is known that such application could potentially improve the long-term performance of those systems. Pressure distribution is also a required component for mounds and sand filters and may be used on all systems that require a pump system.

The potential benefits for using a PDN are:

1. Maintain a uniform effluent application rate
2. Aid in mitigating the potential contamination of groundwater by enhancing aerobic conditions
3. Improve the performance and increase the life span of the disposal area; and
4. Reduce the risk of breakout on slopes

Use Type	Required	Recommended
Mound system	X	
Sand filters (treatment unit)	X	
Long and narrow disposal systems	X	
Conventional drainfield where a pump is required		X
Modified fill type drainfield		X
Irregular disposal areas shapes	X	
Marginal/poor soils	X	
Privately Owned Community Sewage Systems	X	

Plan Preparation and Submittal

PDN design shall be prepared and submitted by a State of Michigan Registered Professional Engineer or Registered Sanitarian.

General Design Specifications

Design Parameter	Specification
Number of effluent doses per day	Must conform to the requirements of the soil texture and structure
Volume of a single dose to a distribution cell	≥ 5 times the void volume of the distribution lateral(s) and ≤ 20% of the Design Wastewater Flow
Head pressure at distal end of lateral(s)	≥ 2.5 ft. for 1/4 and 3/16 inch orifices ≥ 3.5 ft. for 5/32 inch orifices ≥ 5 ft. for 1/8 inch orifices
Network pressure compensation for fittings	= Distal head pressure **x** 1.3
Flow velocity in force main and manifold	≥ 2 ft/sec and ≤ 10 ft/sec
Diameter of force main	≤ 3 inch
Diameter of manifold	≥ 1-1/4 inch, but not > 3 inch
Diameter of lateral	≥ 3/4 inch, but not > 3 inch
Diameter of discharge orifice	= 1/8, 5/32, 3/16 or 1/4 inch
Distance between laterals	≤ 4 feet within same cell
Distance from lateral to edge of distribution cell	≤ 1/2 the distance between laterals, but not >2 feet
Distance from discharge orifice to end of distribution cell	≥ 6 inches, but not > 2 feet
Elevation of laterals	Level or ≤ 1 inch slope back to manifold
Turn ups/flushing valves	Provide a means of flushing out all laterals. Turn-ups are installed in a protective enclosure
Dose tank or compartment volume	≥ Volume of a single dose + avg. daily flow + drain back volume + volume needed to keep pump submerged
Orifice discharge rates variation within any lateral	≤ 10%
Orifice loading	6-10 ft^2 /orifice
Stone depth below lateral	4-6 inches of 6A stone below lateral

General Construction Specifications and Standards

Item	Specifications and Standards
Pipe material	Schedule 40: ASTM D1785
Orifice shields	Required on all orifices; The shields must be strong enough to withstand the weight of the backfill and large enough to protect the orifice from being plugged by gravel.
Cleanouts and maintenance ports	All pressure distribution laterals must be equipped with cleanouts and monitoring ports at the distal ends. Threaded removable caps or plugs on the ends of the laterals to allow for cleaning the laterals must be provided.
Orifice orientation	6 or 12 o'clock position; Design specific.
Pumps	All pumps must be fitted with unions, valves and electrical connections necessary for easy pump removal and repair. All pumps must be protected by approved outlet baffle screens in the chamber preceding the pump chamber or by pump screens. Pumps and electrical hook-ups must conform to all local electrical codes. If any portion of the pump fittings or transport line is at a higher elevation than the drainfield, the system must be equipped with an air vacuum release valve or other suitable device to avoid siphoning.
General construction considerations	Holes are drilled perpendicular to the pipe in a straight line. Use a sharp drill bit to drill a more uniform perforation; Don't use a dull drill. Any burrs or rough edges must be removed from the holes so they do not collect debris and clog. Slide a rod or small diameter pipe along the inside of the lateral pipe to remove burrs. Upon installation, the pipe must be clean and clear of debris and PVC cuttings that can clog holes. During construction, protect the ends of pipes to keep rodents and their food and nesting material out of pipes.

Operation and Maintenance

A PDN must be monitored and maintained at a regular frequency depending on site and system complexity and use. As a minimum, it is strongly recommended that the following be inspected on an annual basis:

1. Evaluate drainfield area for ponding or leakage.
2. Evaluate laterals for residual pressure at the distal ends. Confirm that it is the same or close to those used for design. If not the same, laterals and orifices need to be cleaned.
3. Measure pump run time per cycle and drawdown. If not the same, evaluate the system for improperly set timer control, float switches, clogged laterals, and plugged orifices.
4. Test alarms for proper functioning.
5. Evaluate septic tank and pump chamber for sludge and scum accumulation; leakage; and structural integrity.
6. Evaluate and clean effluent filter or pump screen.

Pressure Distribution Network Design

Steps to design the distribution network:

1. **Determine lateral length, ft**
   - End manifold, lateral length = length of absorption area – 0.5
   - Central manifold = ((absorption area length/ 2) – 0.5)

2. **Determine orifice spacing**
   - Spacing = (area/orifice x no. of lateral)/absorption area width
   - Recommended area / orifice = 6-10 ft^2
   - Typical spacing is 36 in. A larger spacing may be allowed to reduce pipe and pump sizing.

3. **Select perforation size**
   - Recommend using 3/16 in orifices but smaller or larger orifices can be used depending on system specifics and the level of treatment provided prior to final disposal.

4. **Select orifice orientation**
   - Recommend that orifices be oriented downwards to ensure complete draining of lateral to prevent/reduce freezing.

5. **Select lateral diameter/size**
   - Use Table 1 to determine lateral pipe size.

6. **Determine number of orifices per lateral**
   - See Figures 1 or 2 for details

     N= L/X + 0.5 ---------------- central manifold
     N= L/X + 1 ------------------ end manifold

     N= number of orifices
     L= lateral length, ft
     X= orifice spacing, ft

7. **Determine lateral discharge rate**
   - Find orifice discharge rate. See Table 7
   - Lateral discharge rate = no. of orifices x discharge per orifice

8. **Determine no of lateral and lateral spacing**
   - Use loading criteria of 6 ft^2/ orifice to determine lateral spacing.

9. **Determine manifold size and length**
   - For small system use manifold size equals to lateral size. For larger system see Tables 2 or 3.

10. **Determine network discharge rate**
    - This is equals to lateral discharge rate x number of laterals
    - Use this number in pump selection.

Steps to design the force main and pump:

1. **Develop a system performance curve**
   - This will predict how the distribution network performs under various flows and pressure. Pump selection involves the calculation of the system total dynamic head (TDH).
   - The TDH that the pump must overcome is the sum of:
     system network head = 1.3 x distal pressure, ft
     static head = elevation difference between pump off and lateral elevation, ft
     Friction loss in the force main. Include all fittings in this calculation.

2. **Determine diameter of force main**

3. **Select pump that best matches flow and TDH by plotting the pump performance curve on the system curve.**

4. **Determine required dose volume**
   - The recommended dose volume is 5 times the network volume.

5. **Size dose chamber per design specifications table**
   - Minimum dose chamber volume 1000 gallons.

6. **Select distance between control floats based on dose volume and tank size**

Useful Equations

Orifice Equation: $Q=12.4*2(D)\sqrt{H}$

Friction Loss Design Equation:

Friction loss in pipes can be calculated using the Hazen-Williams formula:

Original Form: $V = 1.318 * C * R^{0.63} * S^{0.54}$

Where:
V = velocity (ft/sec)
C = Hazen-Williams flow coefficient (unitless)
R = hydraulic radius (ft^2/ft)
S = slope of energy grade line (ft/1000 ft)

This equation can be modified through algebraic substitutions and using unit conversions to yield a formula that directly calculates friction loss:

Modified Form: $$f = \frac{10.46 L Q^{1.85}}{C^{1.85} D^{4.87}}$$

Where:
f = friction loss (ft)
D = actual inside pipe diameter (in)
L = length of pipe (ft)
Q = flow (gpm)
C = Hazen-Williams flow coefficient (unitless) = 150

TABLE 1: **Lateral Design Table - Schedule 40 Pipe**

Orifice Diameter (inches)	Lateral Diameter (inches)	Orifice Spacing (feet)	Max. Lateral Length (feet)
1/8	1	1.5	42
1/8	1	2	50
1/8	1	2.5	57.5
1/8	1	3	66
1/8	1	4	80
1/8	1	5	90
1/8	1	6	102
1/8	1.25	1.5	66
1/8	1.25	2	80
1/8	1.25	2.5	92.5
1/8	1.25	3	105
1/8	1.25	4	124
1/8	1.25	5	145
1/8	1.25	6	162
1/8	1.5	1.5	85.5
1/8	1.5	2	104
1/8	1.5	2.5	120
1/8	1.5	3	135
1/8	1.5	4	164
1/8	1.5	5	190
1/8	1.5	6	210
1/8	2	1.5	132
1/8	2	2	160
1/8	2	2.5	185
1/8	2	3	207
1/8	2	4	248
1/8	2	5	290
1/8	2	6	324
5/32	1	1.5	31.5
5/32	1	2	36
5/32	1	2.5	42.5
5/32	1	3	48
5/32	1	4	56
5/32	1	5	65
5/32	1	6	72
5/32	1 1/4	1.5	48
5/32	1 1/4	2	58
5/32	1 1/4	2.5	67.5
5/32	1 1/4	3	75
5/32	1 1/4	4	92
5/32	1 1/4	5	105
5/32	1 1/4	6	120
5/32	1 1/2	1.5	63
5/32	1 1/2	2	76
5/32	1 1/2	2.5	87.5
5/32	1 1/2	3	99
5/32	1 1/2	4	120
5/32	1 1/2	5	140

Orifice Diameter (inches)	Lateral Diameter (inches)	Orifice Spacing (feet)	Max. Lateral Length (feet)
5/32	1 1/2	6	156
5/32	2	1.5	96
5/32	2	2	116
5/32	2	2.5	135
5/32	2	3	150
5/32	2	4	184
5/32	2	5	210
5/32	2	6	240
3/16	1	1.5	24
3/16	1	2	28
3/16	1	2.5	32.5
3/16	1	3	39
3/16	1	4	44
3/16	1	5	50
3/16	1	6	60
3/16	1.25	1.5	37.5
3/16	1.25	2	46
3/16	1.25	2.5	52.5
3/16	1.25	3	60
3/16	1.25	4	72
1/4	1	1.5	16.5
1/4	1	2	20
1/4	1	2.5	22.5
1/4	1	3	27
1/4	1	4	32
1/4	1	5	35
1/4	1	6	42
1/4	1.25	1.5	27
1/4	1.25	2	32
1/4	1.25	2.5	37.5
1/4	1.25	3	42
1/4	1.25	4	48
1/4	1.25	5	55
1/4	1.25	6	66
1/4	1.5	1.5	34.5
1/4	1.5	2	42
1/4	1.5	2.5	47.5
1/4	1.5	3	54
1/4	1.5	4	64
1/4	1.5	5	75
1/4	1.5	6	84
1/4	2	1.5	52.5
1/4	2	2	64
1/4	2	2.5	72.5
1/4	2	3	81
1/4	2	4	100
1/4	2	5	115
1/4	2	6	126

<u>TABLE 2:</u> Orifice diameters of 1/8 in. and 5/32 in. with minimum 5 feet of residual head

Maximum Manifold Length (ft)																																							
Lateral Discharge Rate (gpm)		Manifold Diameter (inches)																																					
Rate (gpm/lateral)		1 1/4						1 1/2						2						3						4						6							
Central Manifold	End Manifold	Lateral Spacing (ft)																																					
		2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10
5	10	6	9	8	12	16	10	8	12	12	18	16	20	14	18	20	30	32	40	30	39	48	60	72	80	48	63	76	96	120	130	100	129	156	204	240	280
10	20	4	3	4	6	8	10	4	6	8	6	8	10	8	12	12	18	16	20	18	24	28	36	40	50	30	39	48	60	72	80	64	81	100	126	152	180
15	30	2	3	4				4	3	4	6	8	10	6	6	8	12	8	10	14	18	20	24	32	30	22	30	36	42	56	60	48	63	76	96	112	130
20	40	2						2	3	4	6			4	6	8	6	8	10	12	15	16	18	24	30	18	24	28	36	40	50	40	51	60	78	96	110
25	50							2	3	4				4	6	4	6	8	10	10	12	12	18	16	20	16	21	24	30	40	40	34	45	52	66	80	90
30	60							2						4	3	4	6	8	10	8	9	12	12	16	20	14	18	20	24	32	40	30	39	48	60	72	80
35	70							2						2	3	4	6			8	9	12	12	16	20	12	15	20	24	24	30	26	36	40	54	64	70
40	80													2	3	4				6	9	8	12	16	10	12	15	16	18	24	30	24	30	36	48	56	70
45	90													2	3	4				6	6	8	12	8	10	10	12	16	18	24	20	22	30	36	42	56	60
50	100													2	3					6	6	8	6	8	10	10	12	12	18	24	20	20	27	32	42	48	60
55	110													2	3					4	6	8	6	8	10	8	12	12	18	16	20	20	24	28	36	48	50
60	120													2						4	6	8	6	8	10	8	9	12	12	16	20	18	24	28	36	40	50
65	130													2						4	6	4	6	8	10	8	9	12	12	16	20	18	21	28	36	40	50
70	140													2						4	6	4	6	8	10	8	9	12	12	16	20	16	21	24	30	40	40
75	150																			4	3	4	6	8	10	6	9	8	12	16	20	16	21	24	30	32	40
80	160																			4	3	4	6	8	10	6	9	8	12	16	10	14	18	24	30	32	40
85	170																			4	3	4	6	8		6	9	8	12	16	10	14	18	20	30	32	40
90	180																			2	3	4	6	8		6	6	8	12	8	10	14	18	20	24	32	30
95	190																			2	3	4	6	8		6	6	8	12	8	10	14	18	20	24	32	30
100	200																			2	3	4	6			6	6	8	12	8	10	12	15	20	24	32	30

<u>TABLE 3:</u> Orifice diameter 3/16 in and up with a minimum of 2 feet of residual pressure

Maximum Manifold Length (ft)																																					
Lateral Discharge Rate (gpm/lateral)		Manifold Diameter (inches)																																			
		1 1/4						1 1/2						2						3						4						6					
		Lateral Spacing (ft)																																			
Central Manifold	End Manifold	2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10	2	3	4	6	8	10
5	10	4	6	4	6	8	10	6	6	8	12	8	10	10	12	16	18	24	20	22	27	32	42	48	60	34	45	52	72	80	90	72	93	112	144	176	200
10	20	2	3	4				2	3	4	6	8		6	6	8	12	8	10	12	15	20	24	32	30	22	27	32	42	48	60	46	57	72	90	112	120
15	30	2						2	3	4				4	6	4	6	8	10	10	12	12	18	24	20	16	21	24	30	40	40	34	45	52	66	80	90
20	40							2						2	3	4	6	8		8	9	12	12	16	20	12	18	20	24	32	30	28	36	44	54	64	80
25	50													2	3	4				6	9	8	12	16	10	10	15	16	18	24	30	24	30	36	48	56	60
30	60													2	3	4				6	6	8	6	8	10	10	12	16	18	24	20	22	27	32	42	48	60
35	70													2	3					4	6	8	6	8	10	8	12	12	18	16	20	18	24	28	36	40	50
40	80													2						4	6	4	6	8	10	8	9	12	12	16	20	18	21	28	36	40	40
45	90																			4	3	4	6	8	10	6	9	8	12	16	20	16	21	24	30	32	40
50	100																			4	3	4	6	8	10	6	9	8	12	16	10	14	18	24	30	32	40
55	110																			2	3	4	6	8		6	6	8	12	8	10	14	18	20	24	32	30
60	120																			2	3	4	6			6	6	8	12	8	10	12	15	20	24	32	30
65	130																			2	3	4	6			6	6	8	6	8	10	12	15	20	24	24	30
70	140																			2	3	4				4	6	8	6	8	10	12	15	16	24	24	30
75	150																			2	3	4				4	6	8	6	8	10	10	15	16	18	24	30
80	160																			2	3	4				4	6	4	6	8	10	10	12	16	18	24	30
85	170																			2	3					4	6	4	6	8	10	10	12	16	18	24	20
90	180																			2	3					4	3	4	6	8	10	10	12	12	18	24	20
95	190																			2	3					4	3	4	6	8	10	8	12	12	18	16	20
100	200																			2						4	3	4	6	8	10	8	12	12	18	16	20

TABLE 4: Friction Loss (ft/100 ft) in Plastic Pipes

Flow (GPM)	Nominal Pipe Size (inches)							
	3/4	1	1 1/4	1 1/2	2	3	4	6
1								
2								
3	3.24							
4	5.52							
5	8.34	2.06						
6	11.68	2.88						
7	15.53	3.83						
8	19.89	4.91	1.66			**Velocities in this area are < 2 ft /sec**		
9	24.73	6.1	2.06					
10	30.05	7.41	2.5					
11	35.84	8.84	2.99	1.23				
12	42.82	10.39	3.51	1.44				
13	56	12.04	4.07	1.67				
14		13.81	4.66	1.92				
15		15.69	5.3	2.18				
16		17.68	5.97	2.46				
17		19.78	6.68	2.75				
18		21.99	7.42	3.06				
19		24.3	8.21	3.38				
20		26.72	9.02	3.72	0.92			
25		40.38	13.63	5.62	1.39			
30			19.1	7.87	1.94			
35			25.41	10.46	2.58			
40			40.38	13.4	3.3			
45				16.66	4.11	0.57		
50				20.24	4.99	0.69		
60					7	0.97		
70			**Velocities in this area are > 10 ft/sec**		9.31	1.29		
80					11.91	1.66	0.41	
90					14.81	2.06	0.51	
100					18	2.5	0.62	
125						3.78	0.93	
150						5.3	1.31	
175						7.05	1.74	0.24
200						9.02	2.23	0.31
250							3.36	0.47
300							4.71	0.66
350							6.27	0.87

TABLE 5: **Friction Loss for PVC Fittings**

Equivalent Length of Pipe (feet) PVC Pipe Fittings				
Pipe Size (inches)	90^o Elbow	45^o Elbow	Through Tee Run	Through Tee Branch
.5	1.5	0.8	1.0	4.0
.75	2.0	1.0	1.4	5.0
1	2.25	1.4	1.7	6.0
1.25	4.0	1.8	2.3	7.0
1.5	4.0	2.0	2.7	8.0
2	6.0	2.5	4.3	12.0
2 1/2	8.0	3.0	5.1	15.0
3	8.0	4.0	6.3	16.0
4	12.0	5.0	8.3	22.0
6	18.0	8.0	12.5	32.0
8	22.0	10.0	16.5	38.0

TABLE 6: **Volume of Pipe (gallons per foot)**

Type of Pipe			
Nominal Diameter (inches)	PR 160	PR 200	Schedule 40
0.75		0.035	0.028
1	0.058	0.058	0.045
1.25	0.098	0.092	0.078
1.5	0.126	0.121	0.106
2	0.196	0.188	0.174
2.5	0.288	0.276	0.249
3	0.428	0.409	0.384
4	0.704	0.677	0.661
5	1.076	1.034	1.039
6	1.526	1.465	1.501
8	2.586	2.485	
10	4.018	3.861	
12	5.652	5.432	

TABLE 7: **Discharge Rates from Orifices (GPM)**

Distal Head (feet)	Orifice Diameter (inches)			
	1/8	5/32	3/16	1/4
2.5	NA	NA	0.66	1.17
3	NA	NA	0.72	1.28
3.5	NA	0.54	0.78	1.38
4	NA	0.58	0.83	1.47
4.5	NA	0.61	0.88	1.56
5	0.41	0.64	0.93	1.65

FIGURE 1: **Central Manifold Configuration**

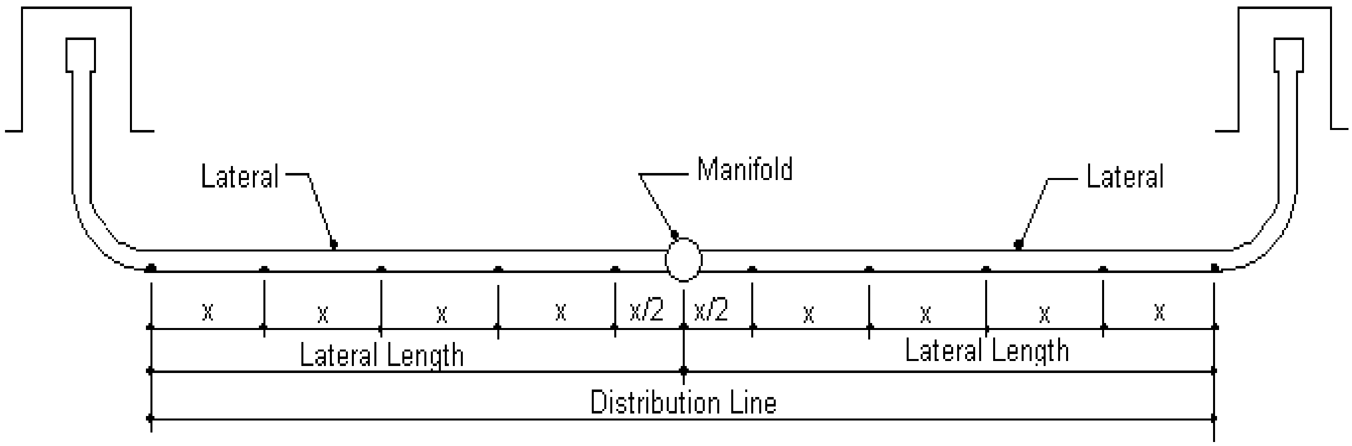
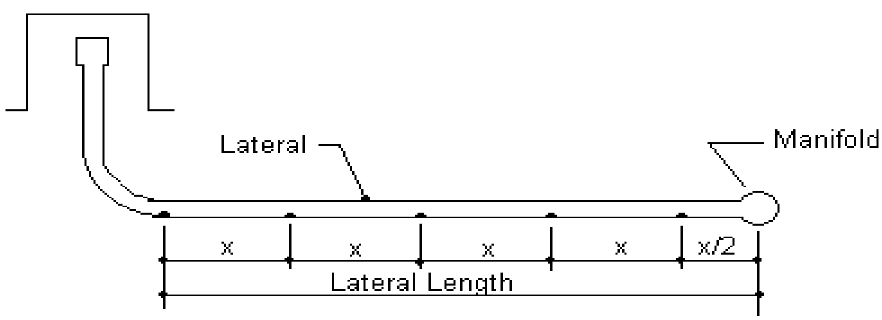


FIGURE 2: **End Manifold Configuration**



Pump Size Selection Example

Assumptions:
Central manifold
Orifice size: 3/16”
Distal head required: 3.5 ft
Number of orifices: 76
Number of laterals: 4
Lateral length: 56 ft
Number of orifices per lateral: 19
Static head: 9 ft
Force main size: 2 in
Force main length: 125 ft
Equivalent length of fittings: 27 ft

From Table 7, discharge rate: 0.78 gpm/orifice
Lateral discharge rate: 19 x 0.78 = 14.8 gpm/ lateral
Network discharge rate: 4 lateral x 14.8 gpm/ lateral = 60 gpm

Total dynamic head TDH = system head + static head + head loss in force main and fittings

System head: 1.3 x distal head = 1.3 x 3.5 = 4.5 ft
Elevation head = 9 ft
Head loss in force main table 6 = 7 (125 + 27) / 100 = 10.6 ft

TDH = 4.5 + 9 + 10.6 = 24.1 ft.

Pump must discharge **60 gpm** against **24 ft** of head with 2 in force main.

Determine system performance curve:
To obtain a system performance curve, use two flows above and two flows below system discharge rate of 60 gpm.

Total Flow (gpm)	Orifice Flow (gpm)	Static Head	Force Main Head Loss	Network Head Loss	TDH
40	40/76 = 0.526	9	3.3(125+27)/100 = 5	2.1	16
50	0.658	9	7.6	3.3	20
60	0.789	9	10.6	4.7	24
70	0.921	9	14.2	6.4	30
80	1.053	9	18.1	8.4	35.5

NETWORK HEAD LOSS = $1.3\ (Q/(11.79d^2)\ )^2$

Where Q = discharge in gpm
d = orifice diameter in inches

To determine system operating point, plot the total flow and TDH from above table on the pump performance curve. The intersection point of the two curves is the system operating point. The pump curve cannot be below the operating point at which you want the system to operate. Pick a pump and pump curve that is as close to the operating point but above the point as possible.

PRESSURE DISTRIBUTION NETWORK WORKSHEET

PARAMETER	QUANTITY	UNIT	DESCRIPTION
General			
Wastewater volume		GPD	
Soil loading rate		GPD/SF	
System Configuration			
Absorption system width		FT	
Absorption system length		FT	
Proposed Lateral Layout			
Number of laterals			
Central or end manifold			
Manifold length		FT	
Distal pressure required		FT	
Orifice diameter		IN	
Estimated lateral length		FT	
Orifice Spacing			
Orifice spacing		FT	
Number of orifices per lateral		ORIFICES	
End manifold	number of orifices		lateral length/orifice spacing+0.5
Central manifold	number of orifices		lateral length/orifice spacing+1
System Design			
Final lateral length		FT	# of orifices x orifice spacing - 0.5 orifice spacing
Lateral diameter		IN	table 1
Lateral discharge rate		GPM	discharge rate per orifice(table 7) x orifices per lateral
Manifold diameter		IN	tables 2 or 3
System discharge rate		GPM	# of laterals x discharge rate per lateral
Force Main			
Length of force main		FT	
Force main diameter		IN	
System discharge rate		GPM	already calculated
Friction loss in force main		FT	ft/100 ft x length in 100 ft
Total Dynamic Head			
Distal pressure required		FT	
Network head		FT	1.3 x distal head
Static head		FT	difference between pump off and lateral elevations
Force main losses		FT	
Other losses		FT	
TDH		FT	
Dose volume		GAL	
Pump selection			must be able to deliver discharge volume @ calculated TDH