APPENDIX B

Pressure Distribution Network Design

By: James Converse
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#9.14

PRESSURE DISTRIBUTION NETWORK DESIGN

By

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Septic tank effluent or other pretreated effluent can be distributed in a soil treatment/dispersal unit either by trickle, dosing or uniform distribution. **Trickle flow**, known as gravity flow, occurs each time wastewater enters the system through 4" perforated pipe. The pipe does not distribute the effluent uniformly but concentrates it in several areas of the absorption unit. **Dosing** is defined as pumping or siphoning a large quantity of effluent into the 4" inch perforated pipe for distribution within the soil absorption area. It does not give uniform distribution but does spread the effluent over a larger area than does gravity flow. Uniform distribution, known as pressure distribution, **distributes the effluent somewhat uniformly throughout the absorption area.** This is accomplished by pressurizing relatively small diameter pipes containing small diameter perforations spaced uniformly throughout the network and matching a pump or siphon to the network.

This material has been extracted and modified from a paper entitled “Design of Pressure Distribution Networks for Septic Tank- Soil Absorption Systems” by Otis, 1981. It also includes material from the “Pressure Distribution Component Manual for Private Onsite Wastewater Treatment Systems” by the State of Wisconsin, Department of Commerce, 1999.

Design Procedure

The design procedure is divided into two sections. The first part consists of sizing the distribution network which distributes the effluent in the aggregate and consists of the laterals, perforations and manifold. The second part consists of sizing the force main, pressurization unit and dose chamber and selecting controls.

A. Design of the Distribution Network:

Steps

1. **Configuration of the network.**

   The configuration and size of the soil treatment/dispersal unit must meet the soil site criteria. Once that has been established, the distribution network can be designed.

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2. **Determine the length of the laterals.**

Lateral lengths are defined as the distance length from the manifold to the end of the lateral. For a center manifold it is approximately than one half the length of the absorption area. For end manifolds it is approximately the length of the absorption area. The lateral end about 6" to 12" from the end of the absorption units.

3. **Determine the perforation size, spacing, and position.**

The size of the perforation or orifices, spacing of the orifices and the number of orifices must be matched with the flow rate to the network.

Size: The typical perforation diameter has been 1/4" but, with the advent of the effluent filters, placed in septic tanks to eliminate carry-over of large particles, smaller diameter orifices can be used. Orifices as small as 1/8" are commonly used in sand filter design utilizing orifice shields to protect the orifice from being covered with aggregate. There are also concerns about using the 1/8" orifices as to how well they drain when located downward especially if they have been drilled in the field. Shop drilling the orifices under tight specifications reduces the concern. As a compromise, one might consider using 3/16" diameter orifices which will allow for more orifices than if 1/4" diameter orifices were used. This example will use 3/16" diameter orifices. **A sharp drill bit will drill a much more uniform orifice than a dull drill. Replace drills often. Remove all burrs and filing from pipe before assembling it.**

Spacing: It is important to distribute the effluent as uniformly as possible over the surface to increase effluent/soil contact time to maximize treatment efficiency. Typical spacing has been 30-36" but some designers have set spacing further apart to reduce pipe and pump sizes. Typical spacing for sand filters has been 6 ft^2/orifice. This spacing is being adopted in the Wisconsin Code (1999) for all pressure distribution applications. This example will use the 6 ft^2/orifice.

Positioning: In cold climates, it is essential that the laterals drain after each dose event to prevent freezing. In sand filters, the orifices have been placed upward with the orifice protected with an orifice shield. The laterals are sloped back to the force main for drainage after each dose. Because of the longer laterals normally encountered in mounds the orifices are typically placed downward for draining as it is much more difficult to slope the lateral to the manifold/force main because of their greater length than found in sand filters. However it can be done. The designer/installer may want to consider sloping the pipe back to the manifold, placing the orifices upward with orifice shields or placing a 3 or 4" half pipe over the entire length of the lateral. Another alternative is placing the lateral inside a 4" perforated pipe with orifices downward or with orifices upward and pipe sloped to the manifold.

4. Determine the lateral pipe diameter.

Based on the selected perforation size and spacing, Fig. A-1 through A-3 will be used to select the lateral diameter.

5. Determine the number of perforations per lateral.

Use N = (p/x) + 0.5 for center feed/center manifold or N = (p/x) + 1 for end fed/end manifold where N = number of perforations, p= lateral length in feet and x= perforation spacing in feet. Round number off to the nearest whole number.

6. Determine the lateral discharge rate.

Based on the distal pressure selected, Table A-1 gives the perforation discharge rate. Recommended distal pressures are 2.5 ft for 1/4" orifices, 3.5 ft for 3/16" orifices and 5 ft for 1.8" orifices. The head that the system operates under is controlled where the system curve interacts with the pump curve (Fig. A-4). For this example use 3.5 ft of head.

7. Determine the number of laterals and the spacing between laterals.

Since the criteria of 6 ft^2/orifice is the guideline, the orifice spacing and laterals spacing are interrelated. For absorption area widths of 3 ft, one distribution pipe along the length requires an orifice spacing of 2 ft. For a 6 ft wide absorption area with the same configuration it would require orifice spacing of 1 ft. **Ideally, the best option is to position the perforations to serve a square such as a 2.5 by 2.5 area** but that may be difficult to do but a 2 by 3 is much better than a 6 by 1 area.

8. Calculate the manifold size and length.

The manifold length is the same as the spacing between the outer laterals if the force main comes into the manifold end. For smaller units assume the manifold size is the same as the force main diameter since the manifold is an extension of the force main. There are procedures for determining the manifold size for larger systems (Otis, 1981).

9. Determine the network discharge rate.

This value is used to size the pump or siphon. Take the lateral discharge rate and multiply it by the number of laterals or take the perforation discharge rate and multiply it by the number of perforations.

10. Provide for Flushing of Laterals.

Provisions must be made to flush the laterals periodically, preferably annually. Easy access to lateral ends is essential otherwise, the flushing will not be done. Turn-ups, as used in sand filter technology, is one approach.

B. Design of the Force Main, Pressurization Unit (Pump or Siphon), Dose Chamber and Controls.

Steps

1. Develop a system performance curve.

The system performance curve predicts how the distribution system performs under various flow rates and heads. The flow rate is a function of the total head that the pump works against. As the head becomes larger, the flow rate decreases but the flow rate determines the network pressure and thus the relative uniformity of discharge throughout the distribution network. The best way to select the pump is to evaluate the system performance curve and the pump performance curve. Where the two curves cross, is where the system operates relative to flow rate and head.

The total dynamic head that the pump must work against is the:

1. System network head (1.3 x distal pressure with minimum 2.5 ft.).
2. Elevation difference between the off-float and the highest point in the network.
3. Friction loss in the force main.

The system network head is the pressure maintained in the system during operation to assure relatively uniform flow through the orifices. The 1.3 multiplier relates to the friction loss in the manifold and laterals which assumes that the laterals and manifold are sized correctly. The elevation difference is between the pump off switch and the distribution network in feet (the pump industry uses the bottom of the pump to the net work). The friction loss in the force main between the dose chamber and the inlet to the network is determined by using Table A-2. Equivalent length for fittings should be included but have typically been ignored. They are included in the example problem with equivalent lengths found in Table A-3.

2. Determine the force main diameter.

The force main diameter is determined in Step 1, part B.

3. Select the pressurization unit.

Pumps

The effluent pumps used for pressurizing the distribution networks are either centrifugal effluent pumps or turbine effluent pumps. The turbine effluent pump, which is a sightly modified well pump, is relatively new to the on-site industry. Relatively speaking the centrifugal pump is a higher capacity/ lower head pump with a relatively flat performance curve and the turbine pump is a lower capacity/higher head pump with a relatively steep performance curve. Turbine pumps probably have a longer life. They may be the preferred choice for time dosing because of their longevity relative to stop/starts.

Using pump performance curves, select the pump that best matches the required flow rate at the operating head. Plot the pump performance curve on the system curve. Then determine if the pump will produce the flow rate at the required head. Do not undersize the pump. It can be oversized but will be more costly.

Siphons

Care must be taken in sizing siphons. The head that the network operates against has to be developed in the force main by backing effluent up in the pipe. If the discharge rate out the perforations is greater than the siphon flow rate, the distal pressure in the network will not be sufficient. Some manufacturers recommend that the force main be one size larger than the siphon diameter to allow the air in the force main to escape. However, this will reduce the distal pressure in the network which may be below the design distal pressure. Falkowski and Converse, 1988, discuss siphon performance and design.

4. Determine the dose volume required.

The lateral pipe volume determines the minimum dose volume. The recommended dose volume has been 5 - 10 times the lateral volume. Also, it was recommended that the system be dosed 4 times daily based on the design flow which would be about 113 gpdose (450 gpd/ 4). At this rate, some mounds would only be dosed once a day. With the advent of timed dosing where effluent is applied a number of times per day, smaller doses need to be applied. However, sufficient volume needs to be applied to distribute the effluent uniformly across the network. Thus, net dose volume size is 5 times the lateral pipe volume with not over 20% of the design volume/dose. The floats are set based on the net dose volume plus the flow back. Table A-4 gives the void volume for various size pipes.

5. **Size the dose chamber.**

   The dose chamber (Fig. A-5) must be large enough to provide:

   a. The dose volume.
   b. The dead space resulting from placement of the pump on a concrete block.
   c. A few inches of head space for floats
   d. Reserve capacity based on 100 gallons per bedroom.

   If time dosing is selected, the pump chamber or septic tank/pump chamber must have sufficient surge capacity. The reserve capacity normally would be sufficient to handle it in a pump chamber. However, if a turbine pump is used, there may not be enough surge capacity if the pump must be submerged as turbine pumps are relatively tall. If the liquid level needs to be above the pump, sufficient dead space reduces the working volume of the tank. That is not the case for centrifugal pumps.

6. **Select controls and alarms.**

   Select quality controls and alarms. Follow electrical code for electrical connections. Some have to be made outside the dose tank. There are excellent friendly user control panels for timed dosed systems.

DESIGN EXAMPLE

Design a pressure distribution network for the mound as described in the Wisconsin Mound Soil Absorption System Siting, Design and Construction (Converse and Tyler, 2000). The absorption area is 113 ft long by 4 ft wide. The force main is 125 ft long and the elevation difference is 9 ft with three 90^{o} elbows.

A. Design of the distribution network.

Steps:

1. **Configuration of the network.**

   This is a narrow absorption unit on a sloping site.

2. **Determine the lateral length.**

   Use a center feed, the lateral length is:

   Lateral Length = (B / 2) - 0.5 ft   Where: B = absorption length.

= (113 / 2) - 0.5 ft
= 56 ft

3. Determine the perforation spacing and size.

Perforation spacing -

Each perforation covers a maximum area of 6 ft^2. The absorption area is 4 ft wide.

Option 1: Two laterals on each side of the center feed

Spacing = (area/orifice x no. of laterals / (absorption area width)

= (6 ft^2 x 2) / (4 ft)
= 3 ft.

Option 2: One lateral down the center on each side of the center feed:

Spacing = area per orifice / width of absorption area

= 6 ft^2 / 4 ft = 1.5 ft

Best option: Ideally, the best option is to position the perforations to serve a square but that may be difficult to do. In Option 1, each perforation serves a 2' by 3' rectangular area while in option 2, each perforation serves a 1.5 by 4 area. With an absorption area of 6 ft wide with one lateral down the center, perforation spacing would be 1 ft apart and the perforation would serve an area of 6 by 1 ft **which would be undesirable**. The proposed Comm. 83 code (Wisc Adm. Code, 1999) states that laterals have to be within 2.0 ft of the edge of the absorption area to eliminate designs laterals with close spacings.

Perforation size -

Select from 1/8, 3/16 or 1/4". Use 3/16" as per discussion in section “Design Procedure Item A-3.

4. Determine the lateral diameter.

Using **Fig. A-2 (3/16")**:

Option 1: For **two laterals** on each side of the center feed and lateral length of 56 ft and 3.0 ft spacing, the **lateral diameter = 1.5"**

Option 2: For one lateral on each side of center feed and lateral length of 56 ft and 1.5 ft spacing, **the lateral diameter = 2".**

5. Determine number of perforations per lateral and number of perforations.

Option 1: Using 3.0 ft spacing in 56 ft yields:

N = (p/x) +0.5 = (56 / 3.0) +0.5 = 19 perforations/lateral

Number of perforations = 4 lateral x 19 perforations/lateral = 76

Option 2: Using 1.5 ft spacing in 56 ft yields:

N = (p/x) + 0.5 = (56/ 1.5) + 0.5 = 38 perforations/ lateral

Number of perforations = 2 laterals x 38 perforations/lateral = 76

Check - Maximum of 6 ft^2 / perforation =

Number of perforations = 113 ft x 4 ft / 6 ft^2 = 75 so ok.

6. Determine lateral discharge rate (LDR).

Using network pressure (distal) pressure of 3.5 ft and 3/16" diameter perforations, Table A-1 gives a discharge rate of 0.78 gpm regardless of the number of laterals.

Option 1: LDR = 0.78 gpm/ perforation x 19 perforations = 14.8 gpm

Option 2: LDR = 0.78 gpm/ perforation x 38 perforation = 29.6 gpm

7. Determine the number of laterals.

This was determined in Step 3 and 4.

Option 1: Two laterals on each side of center feed = 4 laterals spaced 2 ft apart.

Option 2: One lateral on each side of center feed = 2 laterals down center of absorption area.

8. Calculate the manifold size.

Option 1. The manifold is same size as force main as it is an extension of the force main or it could be one size smaller. For larger systems, there is a table available by Otis, 1981 and Wisc. Adm. Code.

Option 2. There is no manifold.

9. Determine network discharge rate (NDR)

Option 1. NDR = 4 laterals x 14.8 gpm/lateral = 59.2 or 60 gpm

Option 2. NDR = 2 laterals x 29.6 gpm/lateral = 59.2 or 60 gpm

Pump has to discharge a minimum of 60 gpm against a total dynamic head yet to be determined.

10. Total dynamic head.

Sum of the following:

System head = 1.3 x distal head (ft)
= 1.3 x 3.5 ft
= 4.5 ft

Elevation head = 9.0 ft (Pump shut off to network elevation)

Head Loss in Force Main = Table A-2 and A-3 for 60 gallons and 125 ft of force main and 3 elbows.

Equivalent length of pipe for fittings - Table A-3

Option A: 2" diameter force main = 3 elbows @ 9.0 ft each = 27 ft of pipe equivalent.

Option B: 3" diameter force main = 3 elbows @ 12.0 ft each = 36 ft

Head Loss = Table A-2

Option A: 2" diameter force main = 7.0 (125 ft + 27 ft)/100 =
= 10.6 ft

Option B: 3" diameter force main = 0.97(125 ft + 36 ft) 100 =
= 1.6 ft

Total Dynamic Head (TDH)

Option A: TDH = 4.5 + 9 + 10.6 = 24.1 ft (2" force main)

Option B: TDH = 4.5 + 9 + 1.6 = 15.1 ft (3" force main)

11. **Pump Summary**

Option A: Pump must discharge 60 gpm against a head of 24.1 with 2" force main.

Option B: Pump must discharge 60 gpm against a head of 15.1 ft with 3" force main.

These are the calculated flow and head values. The actual flow and head will be determined by the pump selected. A system performance curve plotted against the pump performance curve will give a better estimate of the flow rate and total dynamic head the system will operate under. The next section gives an example.

Design of the Force Main, Pressurization Unit, Dose Chamber and Controls

Steps

1. **Calculate the system performance curve.**

Use the following table to develop a system performance curve. Follow procedures (a) through (g) which is listed below the table. Orifice is synonymous to perforation. **This example uses Option A. Option B can be calculated similarly.**

Total Flow	Orifice Flow	Elevation Difference	Force Main	Network Head	Total Head
--------(gpm)-----------		---------------------------(ft)-------------------------------------			
40	0.526	9	5.0	2.1	16.1
50	0.658	9	7.6	3.3	19.9
60	0.789	9	10.6	4.7	24.3
70	0.921	9	14.2	6.4	29.6
80	1.053	9	18.1	8.4	35.5

Procedure:

a. Select 5 flow rates above and below the network discharge rate of 60 gpm.

b. Calculate the orifice (perforation) flow rate for each of the flows. This is done by dividing the flow rate by the number of orifices in the network. For the 30 gpm and 76 orifices, the orifice flow rate is 0.395 gpm.

c. The elevation head is the height that the effluent is lifted.

d. The force main head is the head loss in the force main for the given flow rate. Table A-2 gives the friction loss. Need to select a force main diameter. For this example use 2" force main. For the 60 gpm the friction loss is 7.0 ft x 1.52 for head of 10.6 ft.

e. The network head is calculated by $H = 1.3(Q/(11.79d^2))^2$. H is head in ft, Q is orifice flow rate in gpm, and d is orifice diameter in inches. The 1.3 is an adjustment factor for friction loss in laterals. For 3/16" diameter orifice the equation is $H = 1.3(Q/0.4145)^2$.

f. The total head is the sum of the elevation, force main and network heads.

2. Determine the force main diameter.

Force main diameter:

Option A: = 2" (determined in Step 1 of Section B).

Option B: = 3"

3. Select the pressurization unit.

Plot the performance curves of several effluent pumps and the system performance curve (Fig. A-8). For the system curve plot the flow rates vs. he total head. On the system curve, using an X where the flow rate intersects the curve (in this case 60 gpm). Select the pump, represented by the pump performance curve, located next along the system performance curve just after 60 gpm (Pump B) as that is where the pump will operate. Pump C could be selected but it is over sized for the unit.

4. Determine the dose volume.

More recent thinking is that the dose volume should be reduced from the larger doses recommended earlier.

Use 5 times the lateral void volume. Use void volume from Table A-4.

	Option 1:	Option 2:
Lateral diameter =	1.5"	2.0"
Lateral Length =	56'	56'
No. of laterals =	4	2
Void volume =	0.092 gal/ft	0.163

Net dose volume

Option 1: = 5 x 56 x 4 x 0.092 = 103 gal./dose

Option 2: = 5 x 56 x 2 x 0.163 = 91.3 gal/dose

Flow back from force main

Option A: 2" force main @ 125 ft @ 0.163 gal./ft = 20.4 gal/dose

Option B: 3" force main@ 125 ft@ 0.0.367 gal/ft = 45.9 gal/dose

Set the floats to dose the combination selected:

Dose volume with Option 1 and Option A = 103 + 20 = 123 gpdose
Dose volume with Option 1 and Option B = 103 + 46 = 146
Dose volume with Option 2 and Option A = 91 + 20 = 111
Dose volume with Option 2 and Option B = 91 + 46 = 137

The net dose volume to the mound will be 91 or 103 gpd with either 20 or 46 gallons flowing back into pump chamber. No check valve is used to prevent flow back in cold climates due to freezing potential. If the dose is limited to 20% of the design flow, Option 1 with net dose of 91.3 is very close to 90 gpdose (450 gpd x 20%). Option 2 does not meet the 20% criteria.

5. Size the dose chamber.

Based on the dose volume, storage volume and room for a block beneath the pump and control space, 500 to 750 gallon chamber will suffice. If timed dosing is implemented, then a larger tank will be required to provide surge storage. Use 2/3 daily design flow for surge capacity.

6. **Select controls and alarm.**

   Demand Dosing: Controls include on-off float and alarm float. An event recorder and running time meter would be appropriate to install. If the pump is calibrated and dose depth recorded, these two counters can be used to monitor flow to the soil unit.

   Time Dosing: The advantage of time dosing provides more frequent doses and levels out peak flows to the soil treatment/dispersal unit. In mounds with longer laterals and larger orifices, compared to shorter laterals and smaller orifices in sand filters, time dosing may not be as appropriate as it is in sand filters.

7. **Select Effluent Filters.**

   Filters must be installed on the septic tank to minimize solids carry-over to the pump chamber. A second filter, located on the pump outlet, will keep any solids falling into the pump chamber from being carried over. Converse (1999) provides information relative to filters.

CONSTRUCTION AND MAINTENANCE

Good common sense should prevail when constructing and maintaining these systems. Good quality components should be used. There is no lack of good components today. Water tight construction practices must be employed for all tanks. Surface runoff must be diverted away from the system. Any settling around the tanks must be filled with the soil brought to grade or slightly above to divert surface waters. Provisions must be incorporated into the lateral design, such as turn-ups, to provide for easy flushing of the laterals as solids will build up and clog the orifices. **DO NOT ENTER THE TANKS WITHOUT PROPER SAFETY EQUIPMENT**.

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Table A-1. Discharge rates from orifices.

	Orifice diameter (in.)				
Pressure	1/8	3/16	1/4	5/16	3/8
(ft)	(gpm)				
2.5	0.29	0.66	1.17	1.82	2.62
3.0	0.32	0.72	1.28	1.00	2.87
3.5	0.34	0.78	1.38	2.15	3.10
4.0	0.37	0.83	1.47	2.30	3.32
4.5	0.39	0.88	1.56	2.44	3.52
5.0	0.41	0.93	1.65	2.57	3.71
5.5	0.43	0.97	1.73	2.70	3.89
6.0	0.45	1.02	1.80	2.82	4.06
6.5	0.47	1.06	1.88	2.94	4.23
7.0	0.49	1.10	1.95	3.05	4.39
7.5	0.50	1.14	2.02	3.15	4.54
8.0	0.52	1.17	2.08	3.26	4.69
8.5	0.54	1.21	2.15	3.36	4.83
9.0	0.55	1.24	2.21	3.45	4.97
9.5	0.57	1.28	2.27	3.55	5.11
10.0	0.58	1.31	2.33	3.64	5.24

Values were calculated as: gpm = $11.79 \times d^2 \times h^{1/2}$ where d = orifice dia. in inches, h = head feet.

Table A-2. Friction loss in plastic pipe.

Flow	Nominal Pipe Size						
(gpm)	3/4	1	1-1/4	1-1/2	2	3	4
				(Feet/100 ft of pipe)			
2							
3	3.24						
4	5.52						
5	8.34						
6	11.68	2.88		Velocities in this area are below 2 fps.			
7	15.53	3.83					
8	19.89	4.91					
9	24.73	6.10					
10	30.05	7.41	2.50				
11	35.84	8.84	2.99				
12	42.10	10.39	3.51				
13	48.82	12.04	4.07				
14	56.00	13.81	4.66	1.92			
15	63.63	15.69	5.30	2.18			
16	71.69	17.68	5.97	2.46			
17	80.20	19.78	6.68	2.75			
18		21.99	7.42	3.06			
19		24.30	8.21	3.38			
20		26.72	9.02	3.72			
25		40.38	13.63	5.62	1.39		
30		56.57	19.10	7.87	1.94		
35			25.41	10.46	2.58		
40			32.53	13.40	3.30		
45			40.45	16.66	4.11		
50			49.15	20.24	4.99		
60				28.36	7.00	0.97	
70				37.72	9.31	1.29	
80	Velocities in theses areas				11.91	1.66	
90	exceed 10 fps, which is too great				14.81	2.06	
100	for various flows and pipe diameters				18.00	2.50	0.62
125					27.20	3.78	0.93
150						5.30	1.31
175						7.05	1.74

Note: Table is based on - Hazen-Williams formula: $h = 0.002082L \times (100/C)^{1.85} \times (gpm^{1.85}/d^{4.8655})$ where: h = feet of head, L = length in feet, C= Friction factor from Hazen-Williams (145 for plastic pipe), gpm = gallons per minute, d= nominal pipe size.

Table A-3. Friction losses through plastic fittings in terms of equivalent lengths of pipe. (Sump and Sewage Pump Manufacturers, 1998)

Type of Fitting	Nominal size fitting and pipe					
	1-1/4	1-1/2	2	2-1/2	3	4
90° STD Elbow	7.0	8.0	9.0	10.0	12.0	14.0
45° Elbow	3.0	3.0	4.0	4.0	6.0	8.0
STD. Tee (Diversion)	7.0	9.0	11.0	14.0	17.0	22.0
Check Valve	11.0	13.0	17.0	21.0	26.0	33.0
Coupling/ Quick Disconnect	1.0	1.0	2.0	3.0	4.0	5.0
Gate Valve	0.9	1.1	1.4	1.7	2.0	2.3

Table A-4. Void volume for various diameter pipes.

Nominal Pipe Size (In.)	Void Volume (gal./ft)
3/4	0.023
1	0.041
1-1/4	0.064
1-1/2	0.092
2	0.163
3	0.367
4	0.650
6	1.469

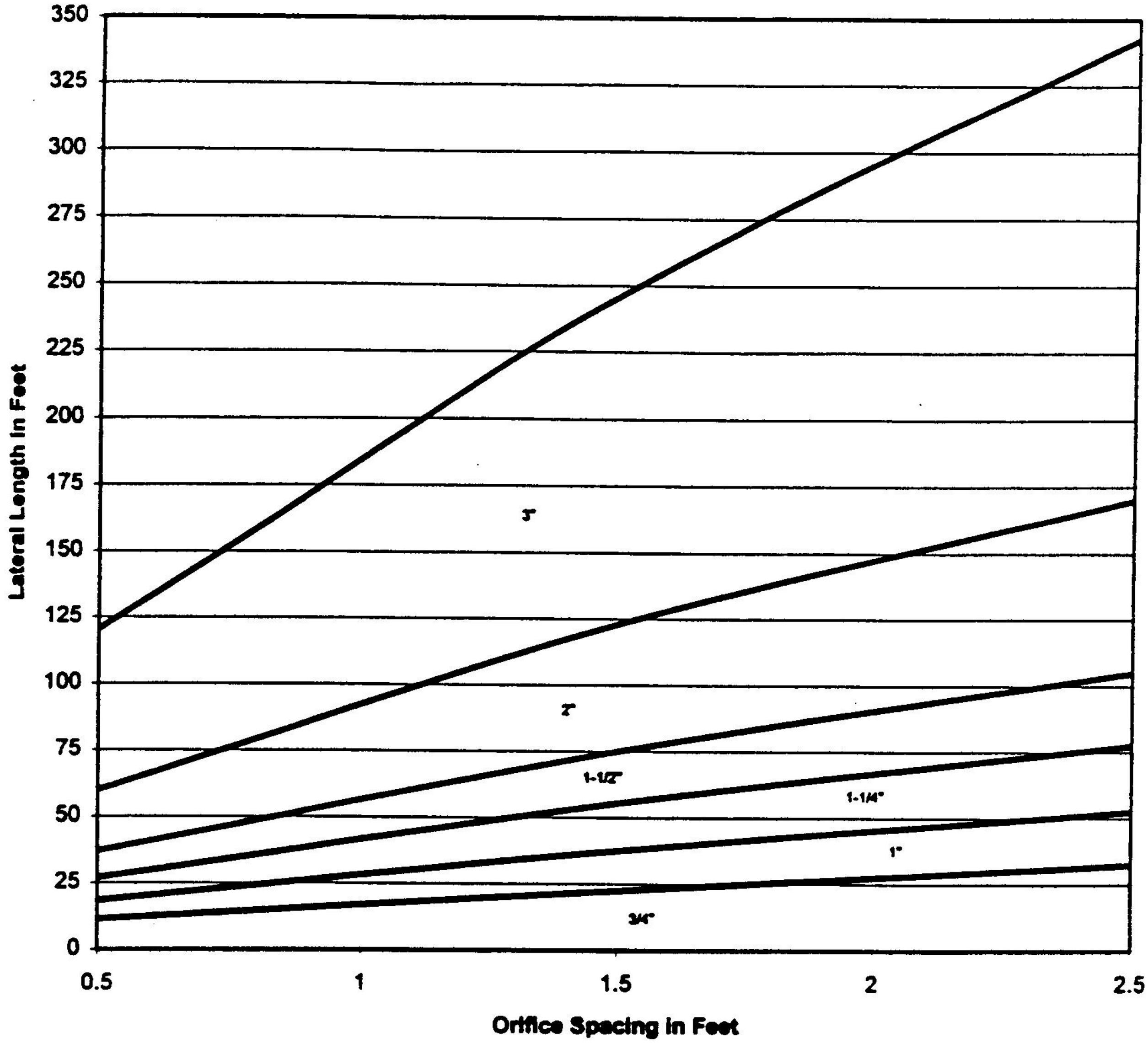


Fig. A -1a. Minimum lateral diameter based on orifice spacing for 1/8 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

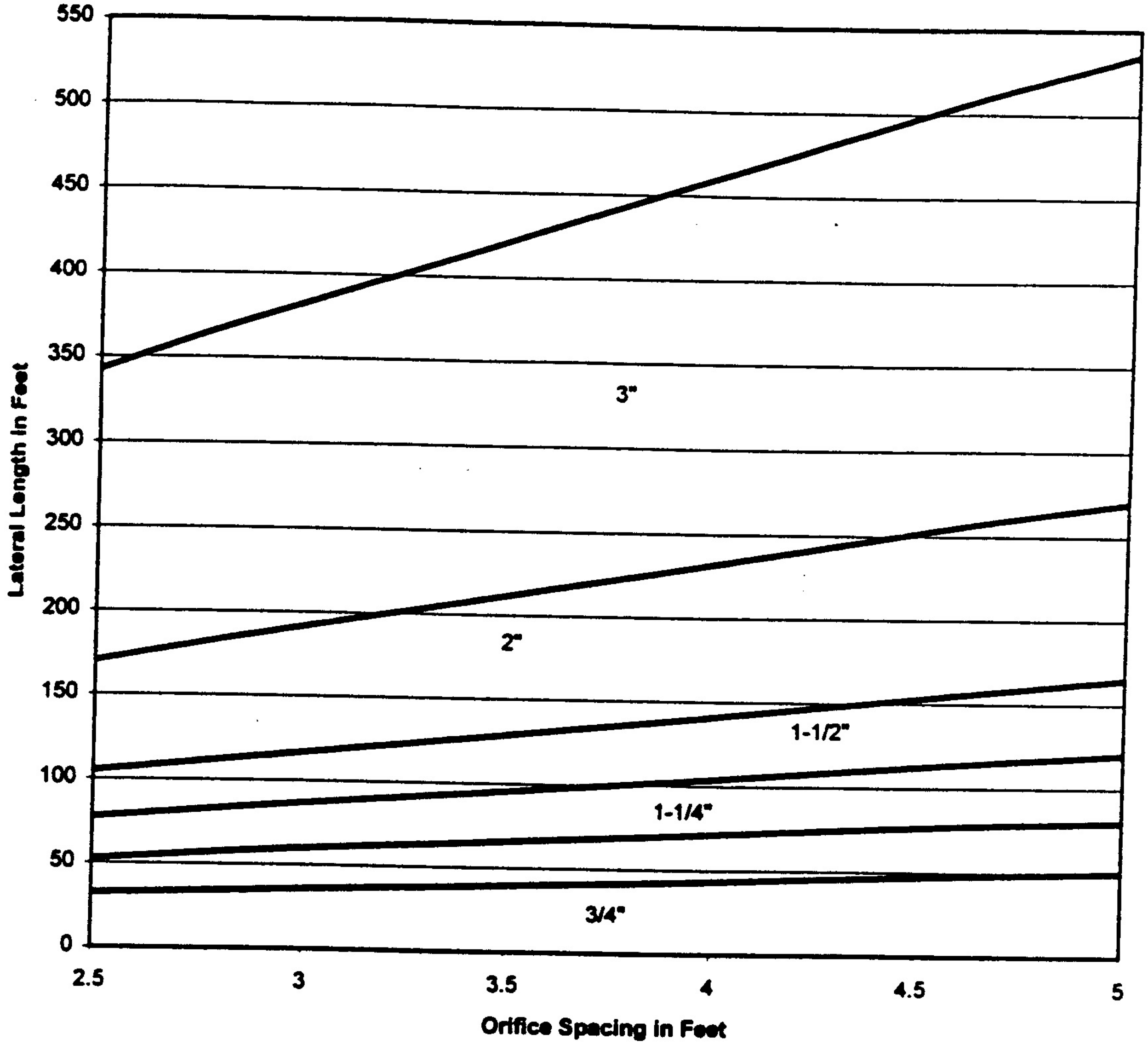


Fig. A -1b. Minimum lateral diameter based on orifice spacing for 1/8 in. diameter orifices (Wisc. Dept. Of Commerce, 1999).

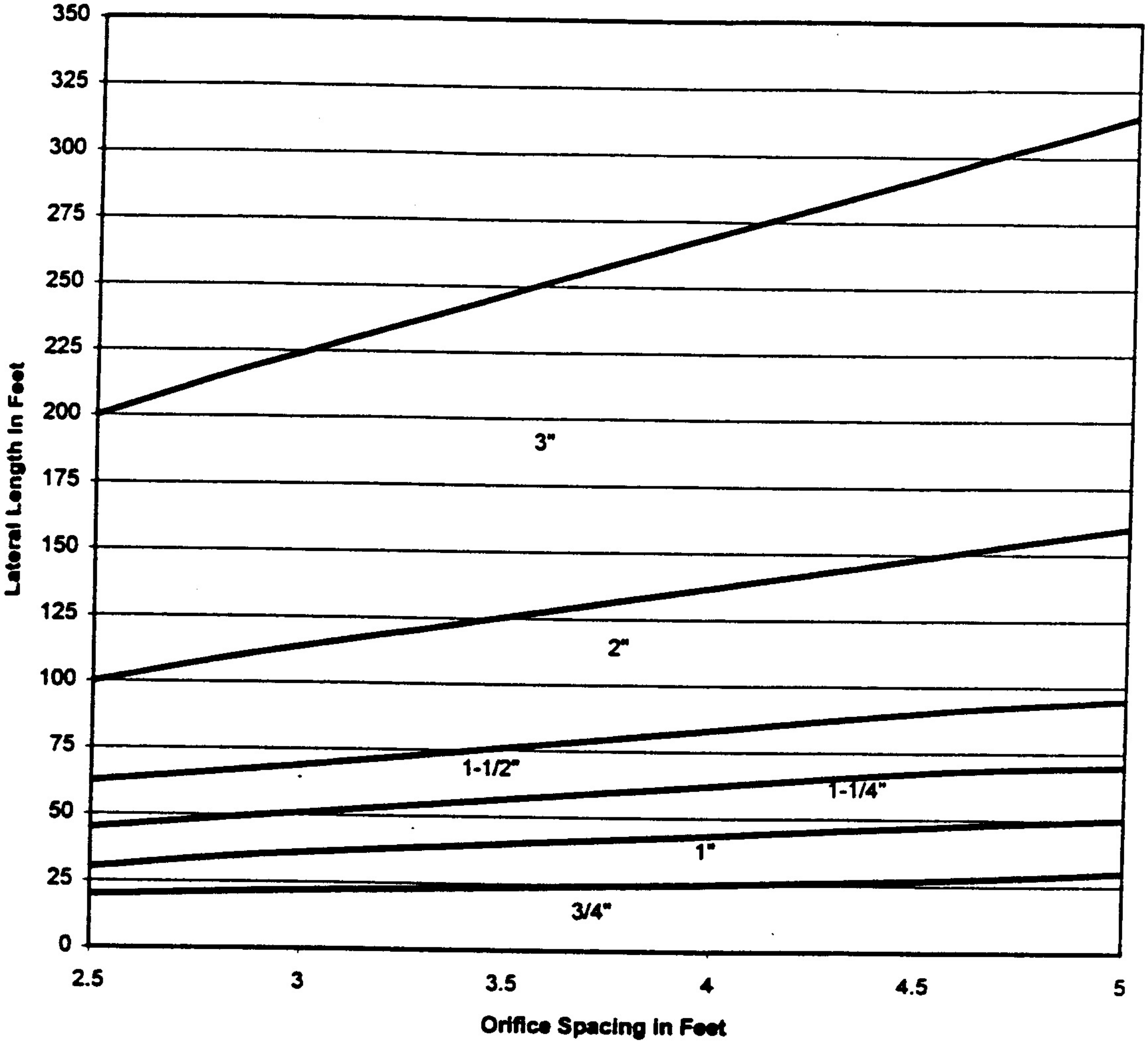


Fig. A -2a. Minimum lateral diameter based on orifice spacing for 3/16 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

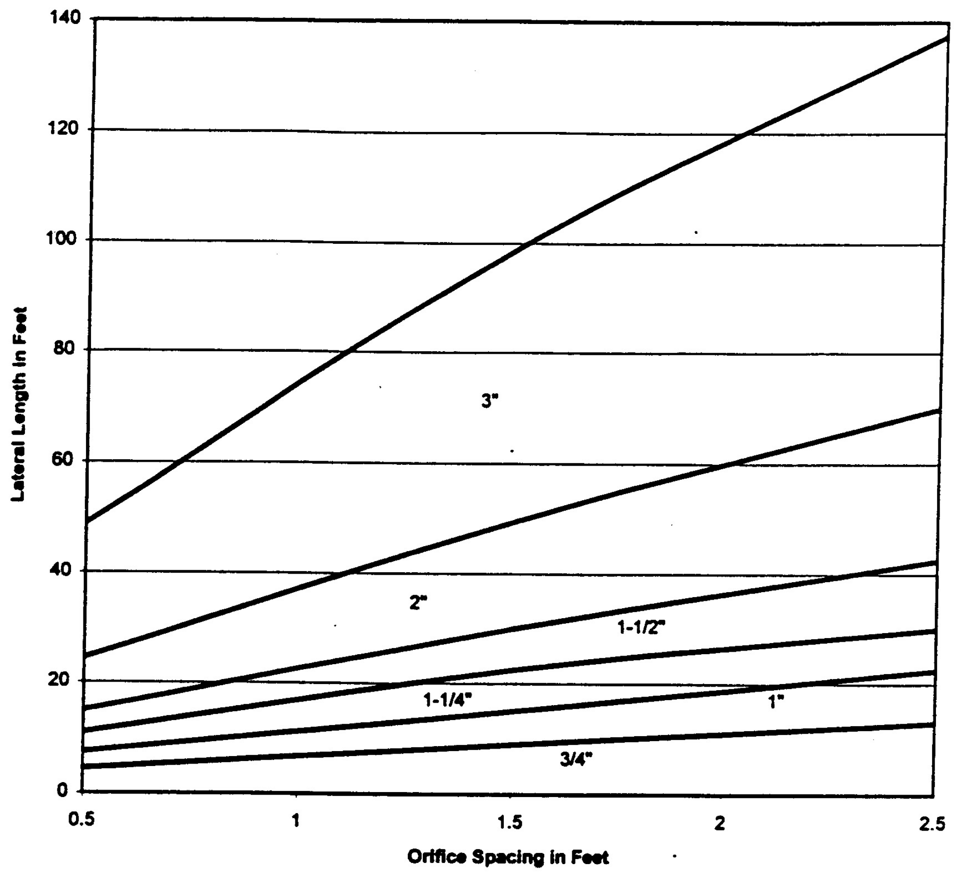


Fig. A -2b. Minimum lateral diameter based on orifice spacing for 3/16 in. diameter orifices (Wisc. Dept. Of Commerce, 1999).

Fig. A -3a. Minimum lateral diameter based on orifice spacing for 1/4 in. diameter orifices (Wisc. Dept. Of Commerce, 1999).

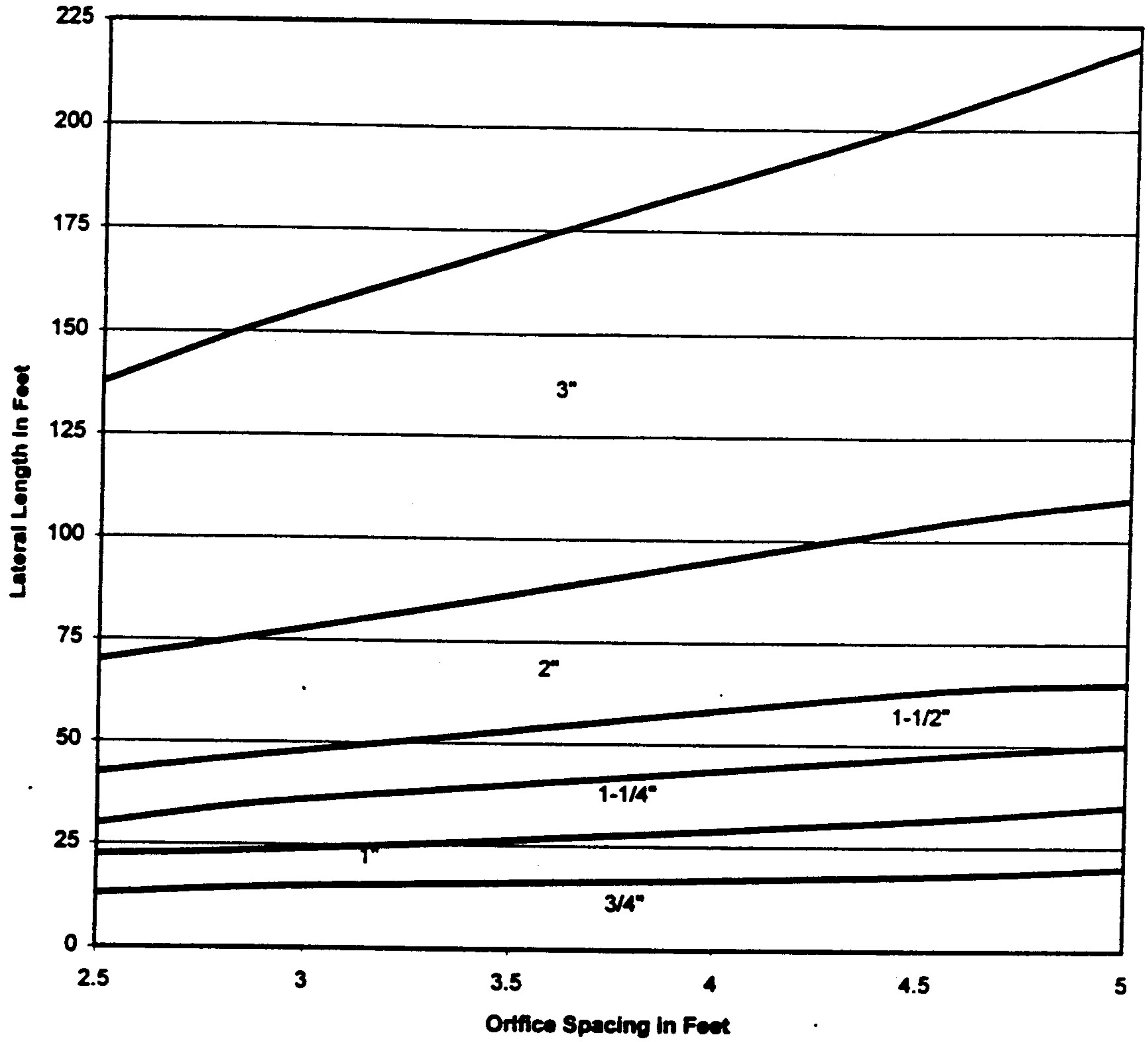


Fig. A -3b. Minimum lateral diameter based on orifice spacing for 1/4 in. diameter orifices (Wisc. Dept. Of Commerce, 1999).

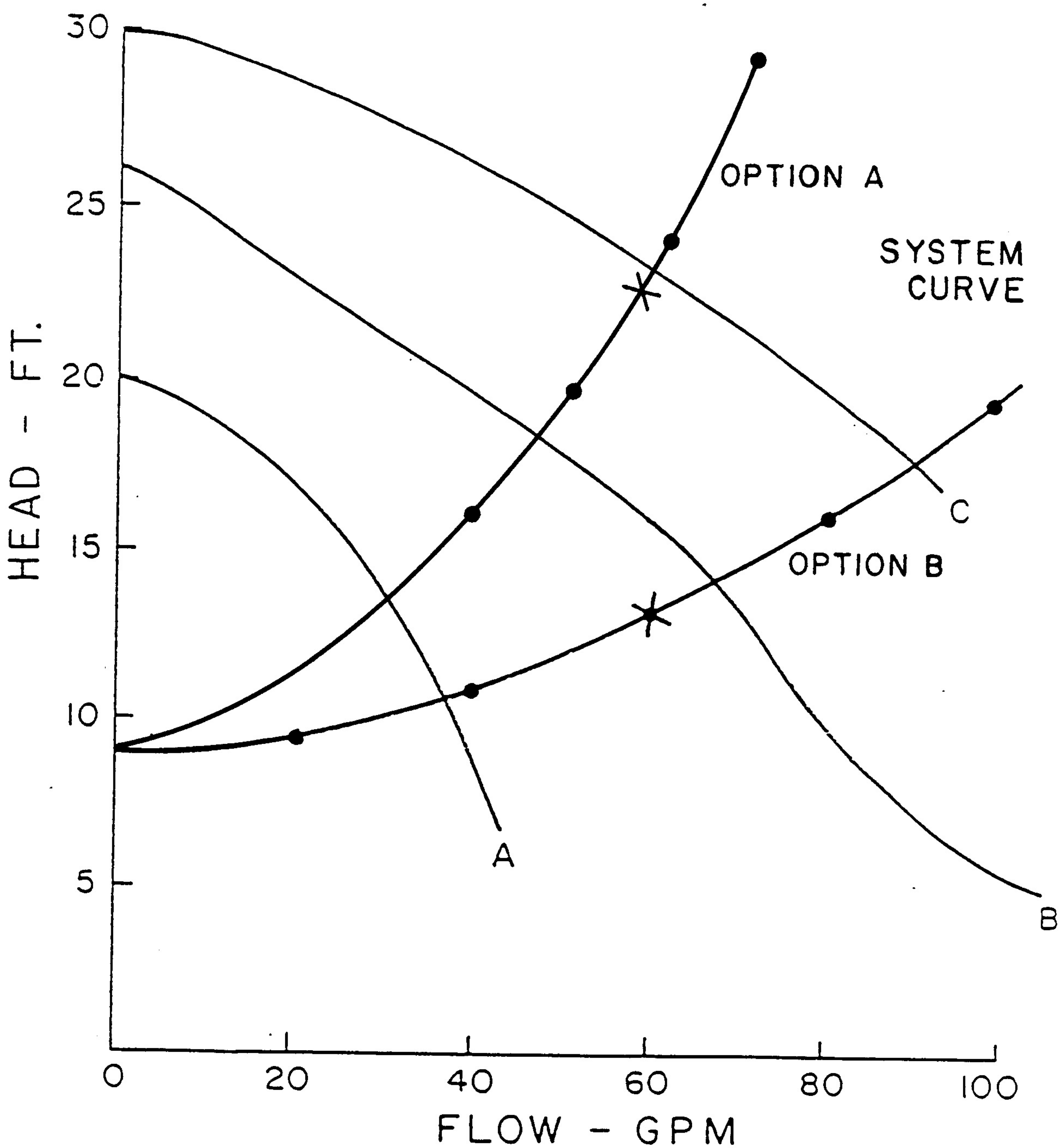
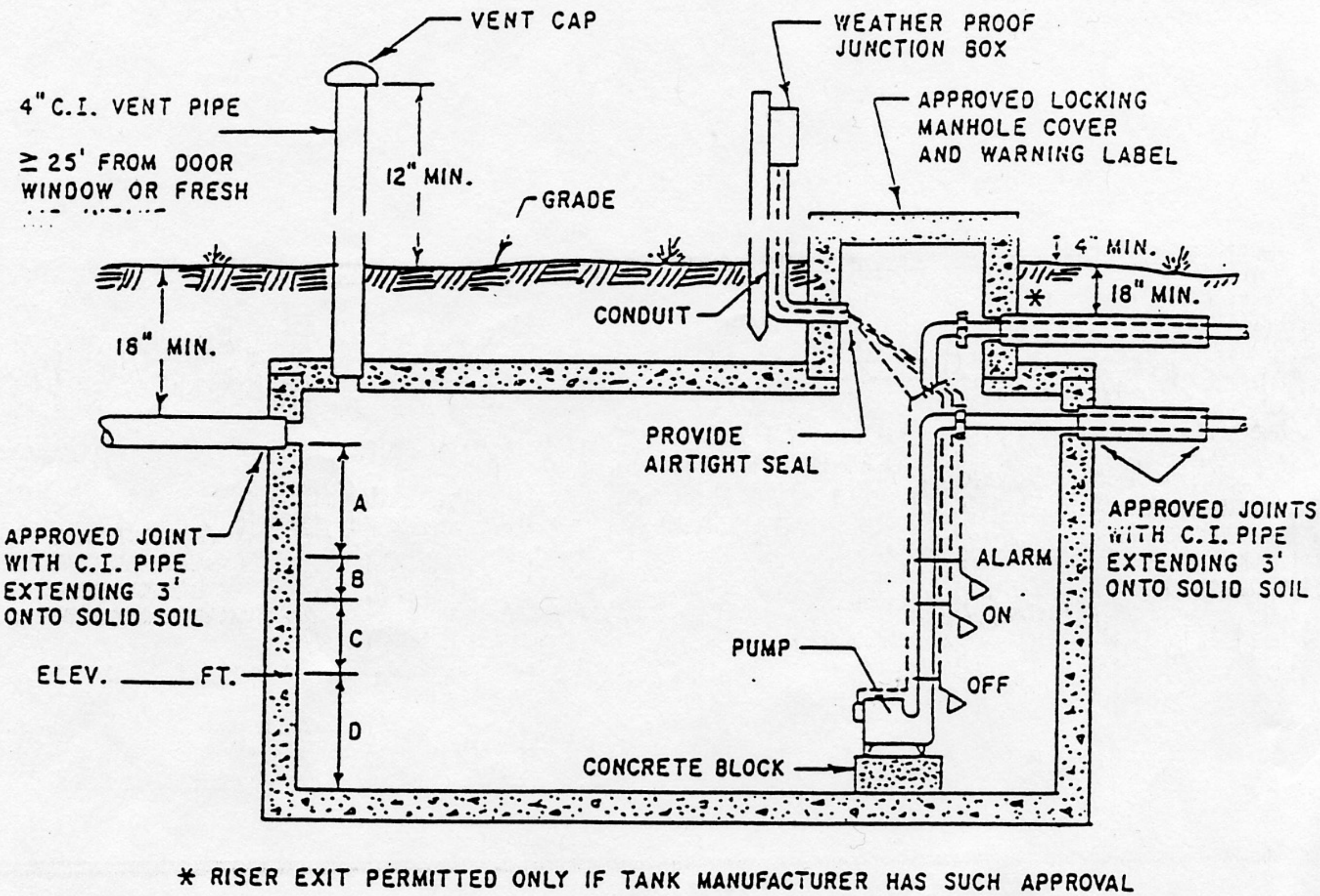


Fig. A-4 System performance curve and several pump performance curves for the example problem. For this example, the pump must provide a flow of at least 60 gpm



(represented by X on the system performance curve. Pump A, represented by performance curve A, will not provide it. Pump C exceeds the requirements considerably and the curves intersect near the end of the pump curve. Pump B is the correct pump to select as it is just slightly above the desired point (X) and it is toward the middle of the pump curve.

Fig. A-5. Cross section of a dose chamber with pump and floats. There are other examples available. Make sure it meets code.