7 Lateral and Submain Design

When determining the allowable fluctuation in the emitter operating pressure within a zone pressure losses due to elevation differences, friction loss in the lateral and friction loss in the submain must be considered. A good guiding principle for lateral design is to ensure that lateral friction losses are less than 15% of the emitter operating pressure. Various design methods can be used to determine the pipe friction loss for submains and laterals. This chapter provides information on calculating friction losses through lateral lines and the submains.

A header line may also be used to flush the ends of the laterals for maintenance purposes. Correct design of the header and flushing valve is important to ensure adequate flushing capacity.

7.1 Lateral Line Design

Once an emitter has been selected, the operating pressure range of the system can be determined. See Chapter 4. The pressure fluctuation with in a zone is determined by the friction loss in the submain and laterals and elevation changes due to terrain. The total head loss due to friction and the loss or gain due to elevation must not exceed the operating pressure range of the emitter. Factors which will affect the hydraulics of the lateral are:

- variation in water temperature along the lateral
- size and shape of the emitter barbs
- variation in wall thickness of the lateral
- shape of the lateral; buried laterals may actually be oval in shape

It is difficult to determine exactly what the lateral friction will be with all of these changing parameters. The pressure differential between the first and last emitter may not provide an accurate picture of the pressure fluctuation along the lateral if the ground is undulating or there is a steep slope. As illustrated in Figure 7.1 there are a number of problems that can arise with changes in pressure and temperature. Problems encountered may include:

- low pressure at high points resulting in lower flow rates
- high pressure at the ends of laterals resulting in higher flow rates
- emitter drainage in low points along the lateral - excessive water will be applied in these locations every time the system is shut down
- algae growth in laterals due to warmer water temperatures

Show effects of lateral operating on a slope and undulating terrain. Indicate seepage from low lying emitters, effects of friction versus pressure gain. Use theoretical numbers to illustrate point.

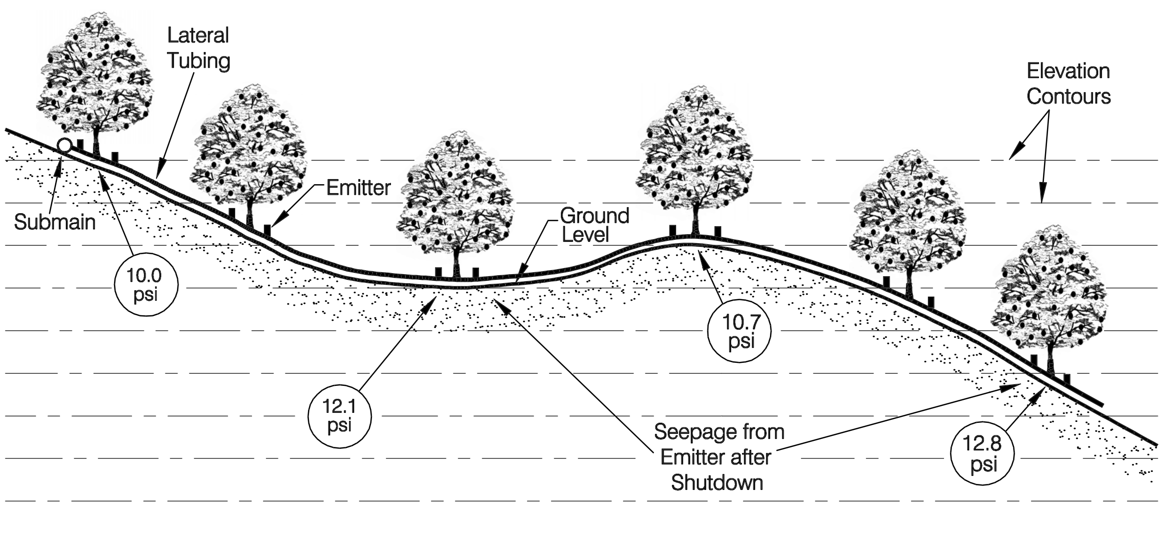


Figure 7.1 *Elevation Effects on Lateral Distribution Uniformity*

7.2 Linear Tape Lateral Design

Linear tape laterals are manufactured with a range of hose diameter, wall thicknesses, orifice spacings and flow rates to match crop and site specific conditions. An explanation of the available options follows.

Hose diameter is selected to match the length of run and the number of orifices. If row lengths are short, smaller hose diameters will be more economical. Conversely, larger diameters must be used for longer rows because there are more orifices that must be supplied.

Wall thickness determines the product durability. For an annual crop such as tomatoes a very light weight tubing (4 mil) may be the most economical. Longer term crops such as strawberries may require a medium weight tubing (10 mil) capable of a 3 to 4 year life span. Heavier weight tubing (15 mil) is available for installation where mechanical, rodent, or field traffic abuse is more likely. Line source laterals are available in wall thicknesses from 4 mil to 25 mil (l mil – 0.00l inch). Tape with heavier wall thicknesses can also be operated at higher pressure ranges than thin walled tape. Manufacturer's charts will often provide this information.

The **orifice spacing** selected is determined by the crop spacing, initial germination requirements and soil capacity for lateral and vertical water movement. Crops that are planted close together, are shallow rooted or growing in a coarse soil may require linear tape systems with orifices spaced at 8" – 12" apart. Crops that are spaced wider apart, have deeper roots and or growing in a medium soil may use spacings that are 12" – 16" apart.

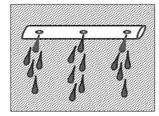
The **flow rate** will depend upon the orifice spacing, operating pressure and length of the lateral. Most drip tape is operated at 8 psi. To maintain uniformity it is not recommended to use drip tape on slopes exceeding 3% as the pressure gain will then exceed friction losses. Some tape systems have an option of a high or a low flow rate. On flat ground, select the lowest flow rate that is capable of supplying sufficient irrigation. This will reduce friction losses, allow longer lateral lengths while still maintaining uniformity. On sloping ground, with laterals that running down hill, the higher flow rate tape may allow for longer runs within the uniformity tolerance. Turbulent flow or pressure compensating tape systems will allow for larger pressure differentials along the lateral while maintaining uniform flow rates. Additional information on system uniformity can be found in Chapter 4.

There are so many options and product lines available that it is impossible to provide all the product specifications in this manual. Specifications for some types of drip tape are included in Appendix B. Table 7.1 provides a summary of the information available. Information from these tables will be used in the examples for this manual. Consult manufacturer's information for the wide variety of options that are available.

Table 7.1 Key to Linear Tape Tables B.1 to B.7 - Appendix B

Table No.	Linear Tape Size
Table B.1	Rain Tape - 5/8 in. I.D.
Table B.2	Rain Tape - 16 mm I.D. (5/8 in. I.D.)
Table B.3	T-Tape TSX 300 - 3/8 in. I.D.
Table B.4	T-Tape TSX 500 - 5/8 in. I.D.
Table B.5	T-Tape TSX 700 - 7/8 in. I.D.
Table B.6	T-Tape TSX Tree and Vine - 5/8 in. I.D.
Table B.7	T-Tape TSX Tree and Vine - 7/8 in. I.D.

Example 7.1 Linear Tape Design for a Strawberry Crop



A strawberry crop on a l ft x 4 ft spacing is being grown in Abbotsford in a sandy loam soil. A linear tape system under a plastic mulch is to be used to irrigate the strawberry field. The trickle system design requirement has been calculated to be 0.29 G/P/D. The field has a 1% slope from one end of the row to the other. The following trickle system design parameters are given:

Plant spacing	l ft x 4 ft
Row Length	400 ft
Number of rows	250
Well supply	30 gpm

An emission uniformity (Eu) of 85% is desired for the laterals.
An Eu for the entire zone of 80% is desired.

With the information provided above, select a linear tape lateral size, calculate the maximum lateral length, the number of laterals per zone, the number of zones, the zone operating time and total system operating time.

Lateral Selection

To ensure good uniformity a 12 in. orifice spacing is selected to accommodate the plant spacing. The submain friction loss must be included to achieve the overall emission uniformity of 80% for the entire zone. To allow for the submain loss a higher Eu should then be selected for just the lateral line. An Eu of 85% is chosen for the lateral to accommodate the submain friction loss and achieve an overall zone Eu of 80%.
Since the rows are not very long a small diameter hose may suffice. For this example T-Tape TSX 300 will be used. The following is a summary of the design parameters used to extract the maximum lateral length information from Table B.3.

outlet spacing = 12 inches
emission uniformity = 85%
slope = 1% downhill

Table B.3 provides additional information on this product.

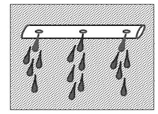
hose diameter = 3/8” diameter
operating pressure = 8 psi is selected

For a 12 inch outlet spacing, 1% downhill slope, an inlet pressure of 8 psi and an EU of 85% the following information can be obtained from Table B.3:

flow rate = 0.45 gpm / 100 ft = maximum length is 300 ft
flow rate = 0.22 gpm / 100 ft = maximum length is 500 ft

(Continued)

Example 7.1 Linear Tape Design for a Strawberry Crop



Maximum Lateral Length

The lower flow rate (0.22 gpm / 100 ft) is selected as the maximum allowable length will then be able to irrigate the entire row. Since the rows are only 400 ft long the actual EU for the lateral only is 90% for this situation. The pressure losses through the submain must also be checked to ensure an overall Eu of 80% is achieved for the zone.

The allowable pressure difference within the zone can be calculated using Equation 4.5 and the process outlined in Section 4.4. To do this the manufacturer's coefficient (Cv) of the product must be known. Table 4.7 provides another option if the emitter flow exponent (x) as well as the Cv is known. For linear tape systems the following guideline can be used to determine the allowable submain friction loss if the C_v of the tape product is not known.

> Since tape systems operate at very low pressures the following guidelines are suggested:
>
> - select a tape and lateral length that has a uniformity of at least 85% and preferably 90%.
> - the maximum pressure variation along the submain should not exceed 1.0 psi if the operating pressure is 8 psi.
> - the maximum submain pressure variation should be limited to 1.5 psi for linear tape operating pressures of 12 psi or more.
>
> If the C_v of the tape is known the information shown in Section 4.4 can be used to determine the maximum allowable pressure variation within a zone. See Example 4.4.

Laterals per Zone

The flow supplied per crop row is:

The low flow T-Tape TSX 300 supplies 0.22 gpm / 100 ft

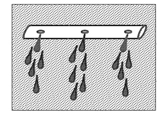
0.22 gpm / 100 ft x 400 ft /row = 0.88 gpm / row

= 0.88 gpm x 60 min /hr = 52.8 gal / hr / row

Maximum number of laterals per zone:

$$= \frac{\text{source supply}}{\text{water required per row}} = \frac{30 \text{ gpm}}{0.88 \text{ gpm /row}} = 34 \text{ rows}$$

(Continued)



Example 7.1 Linear Tape Design for a Strawberry Crop

(Continued)

Number of Zones

$$\text{The number of zones} = \frac{\text{number of rows}}{\text{number of rows per zone}} = \frac{250}{34} = 7.4 \text{ zones}$$

The number of zones must be a whole number. It is easier to set up 8 zones of which 6 will have 31 rows and 2 will have 32 rows.

Maximum zone flow rate = maximum number or rows x flow per row
= 32 rows x 0.88 gpm/row = 28 gpm

Zone Operating Time

Water requirement per row is calculated by determining the number of plants per row and multiplying by the plant water requirement:

$$\frac{\text{Plants}}{\text{row}} = \frac{400 \text{ ft / row}}{1 \text{ ft /plant}} = 400 \text{ plants / row}$$

0.29 G/P/D x 400 plants/row = 116 gal/ row/ day

Operating time per zone is calculated by dividing the water requirement per row by the supply rate to each row:

$$= \frac{\text{water requirement per row}}{\text{water supplied per row}} = \frac{116 \text{ gal /row /day}}{52.8 \text{ gal/hr/row}} = 2.2 \text{ hrs /day / zone}$$

Total System Operating Time

Total system operating time = number of zones x operating time per zone

= 8 zones x 2.2 hrs /day / zone
= 17.6 hours per day

Note:
An example plan of a linear tape system design is shown in Appendix F (Plan No. 565.016) . To make calculations easier a Trickle Irrigation Design Information Sheet is available in Appendix G.

7.3 Spray and Point Source Emitter System Lateral Design

A number of different methods can be used to size the laterals for point and spray emitter systems.

For laterals that have the emitter inserted in the tubing during the extrusion process, a lateral friction loss may often be provided by the manufacturer.

If the emitter is plugged into the lateral or the lateral friction loss is not provided then the specific discharge rate curves shown in Appendix A can be used. An emitter barb friction loss should then be added to determine the total lateral friction loss. The barb loss is estimated by using 30% of the lateral line friction loss.

Lateral with a Single Pipe Size

If single sized polyethylene laterals are used, the laterals can be designed using the specific discharge rate curves shown in Appendix A. The specific discharge rate (SDR) of a lateral line is calculated by:

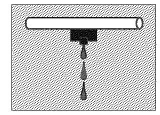
$$\textbf{SDR} = \frac{\textbf{total lateral flow (gph)}}{\textbf{lateral length (ft)}}$$

Laterals with Multiple Pipe Sizes

To design a lateral with multiple pipe sizes the uniplot curves in Appendix D should be used.

The following two examples are similar and use the specific discharge rate to determine lateral line size. Example 7.2 uses the point source emitter example and is on flat terrain. Example 7.3 uses the spray emitter example which is on sloping terrain.

Example 7.2 Point Source Emitter Lateral Design



A tree fruit crop on a 5 ft x 12 ft planting is grown in Kelowna on flat topography in a loam soil. Example 3.2 from Chapter 3 has calculated the plant water requirement to be 7.2 G/P/D. The trickle system design requirement has been calculated to be 9.8 G/P/D.

A trickle system uniformity (EU) of 90% is desired. The manufacturer's variance coefficient (Cv) is 0.07 and the discharge exponent (x) for the emitter selected is 0.5. There are 2 emitters per plant with an operating pressure of 15 psi. The emitters are non pressure compensating and are plugged into the lateral. From Example 4.3, Chapter 4, the allowable pressure difference within the zone is 21% of the average emitter pressure. The operating pressure variance is therefore 3.15 psi.

The trickle system design parameters are:

Trickle System Design Requirement	9.8 G/P/D
Tree spacing	5 ft x 12 ft
Row length	400 ft
Number of rows	150
Water Supply	110 gpm
Emitter selected	2 L/hr point source emitter
Emitter spacing	2.5 ft
Emitter Operating Pressure	15 psi
Operating Pressure Variance	3.15 psi

With the information provided above, select a lateral size, calculate the lateral friction loss, the number of laterals per zone, the number of zones, the zone operating time and total system operating time.

Lateral Selection

A single size lateral line is selected therefore the specific discharge rate (SDR) curves can be used.

$$\text{Lateral line flow rate} = \frac{\text{lateral line length}}{\text{emitter spacing}} \times \text{emitter flow rate}$$

$$= \frac{400 \text{ ft}}{2.5 \text{ ft}} \times 2 \text{ L / hr} = 320 \text{ L /hr}$$

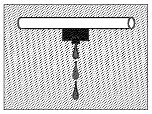
$$= 85 \text{ gph}$$

$$\text{SDR} = \frac{\text{lateral flow}}{\text{lateral length}}$$

$$\text{SDR} = \frac{85 \text{ gph}}{400 \text{ ft}} = 0.21 \text{ gph / ft}$$

(Continued)

Example 7.2 Point Source Emitter Lateral Design



(Continued)

> The pressure variation within the zone must accommodate the elevation difference, lateral friction loss and the submain friction loss. To select an allowable friction loss in the lateral a submain friction loss must first be known. Since this has not yet been calculated start by using a submain loss of 1.5 psi. The lateral friction loss can then be calculated. The actual submain loss allowed can then be determined by subtracting the lateral friction loss from the allowable zone pressure variation.

Since the land topography is flat in this example, the elevation effect is non-existent. The lateral friction loss is therefore limited to the difference between the total allowable zone pressure variation of 3.15 psi and the allowable submain friction loss of 1.5 psi.

Submain friction loss = 3.15 psi - 1.50 psi = 1.65 psi

From Figure A.3 –for an SDR of 0.21 gph/ft and a 400 ft row length the lateral friction loss for l5 mm Polyethylene (PE) is 5 ft (2.2 psi). Note that even without taking into account the barb loss the total friction loss exceeds the allowable loss of 1.65 psi.

From Figure A.6 – the same conditions for 20 mm PE shows a friction loss of 1.0 ft

= 0.43 psi

A lateral length of 400 ft will therefore require 20 mm PE.

If the submain were to bisect the tree rows then the lateral length would be only 200 ft. This will allow for smaller lateral tubing to be used.

From Figure A.2 – for an SDR of 0.21 gph/ft and a row length of 200 ft the friction loss for l3 mm PE is 1.25 ft (0.54 psi).

Depending on the layout of the submain either 20 mm or 13 mm polyethylene should be used. In most instances 13 mm would be selected to reduce system cost.

Allowable Submain Loss

Using the 13 mm polyethylene, the total lateral friction loss including the emitter barb loss is:

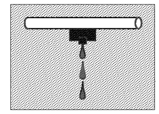
Emitter barb loss is equal to 30% of lateral loss = 0.30 x 0.54 = 0.16 psi

Total lateral loss = 0.54 psi + 0.16 psi = 0.70 psi

The allowable submain loss is then 3.15 psi - 0.70 psi = 2.45 psi

(Continued)

Example 7.2 Point Source Emitter Lateral Design



(Continued)

Number of Laterals per Zone

Water required per row $= \dfrac{85 \text{ gph}}{60 \text{ min/hr}} = 1.42 \text{ gpm}$

Maximum number of laterals per zone:

$$= \frac{\text{source supply}}{\text{water required per lateral}} = \frac{110 \text{ gpm}}{1.42 \text{ gpm / lateral}} = 77 \text{ laterals}$$

Number of Zones

$$\text{The number of zones} = \frac{\text{number of laterals}}{\text{number of laterals per zone}} = \frac{150}{77} = 1.94 \text{ zones}$$

Since the number of zones must be a whole number, the system will require 2 zones of 75 laterals each.

Zone Flow Rate

The flow rate for each zone will then be:

$$= 1.42 \text{ gpm/ lateral} \times 75 \text{ laterals} = 107 \text{ gpm}$$

Zone Operating Time

The water is supplied to each plant by two emitters operating at 2 L/hr each. The water supplied is therefore 4 L/hr or 1.06 gph.

Operating time per zone:

$$= \frac{\text{trickle system design requirement}}{\text{water supplied per plant}} = \frac{9.8 \text{ G/P/D}}{1.06 \text{ gph}} = 9.2 \text{ hrs /day / zone}$$

Total System Operating Time

Total system operating time = number of zones x operating time per zone

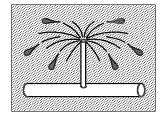
= 2 x 9.2 hrs /day / zone

= 18.4 hours per day during peak conditions

Note:

An example plan of a point source system design is shown in Appendix F (Plan No. 565.015). To make calculations easier a Trickle Irrigation Design Information Sheet is available in Appendix G.

Example 7.3 Spray Emitter Lateral Design



A tree fruit crop on a l0 ft x 20 ft planting is grown in Osoyoos in a loamy sand soil. Example 3.4 has calculated the plant water requirement to be 26.7 gallons per plant per day. The land has a slope of 2% along the lateral.

The trickle system design parameters are:

Trickle Design Requirement	40.7 G/P/D
Tree spacing	10 ft x 20 ft
Row length	400 ft
Number of rows	100
Water Supply	130 gpm
Emitter selected	0.03" orifice - l80^{o} spray emitters
Emitter spacing	2 emitters per tree - one on each side of the tree trunk
Emitter operating pressure	l5 psi
Emitter flow rate	From table 5.1 - a 0.03" orifice @ 15 psi - 4.9 gph

A trickle system uniformity (EU) of 85% is desired. The manufacturer's variance coefficient (Cv) is 0.10 and the discharge exponent (x) for the emitter selected is 0.6. The allowable pressure variation can be determined from Table 4.7.

$$EU_{cv} = 1 - 1.27 \frac{(0.10)}{\sqrt{2}} = 0.91$$

Allowable Zone Pressure Variation

From Table 4.7, for system uniformity of 85% (0.85), an Eu_{cv} of 0.91 and an x value of 0.60 the allowable pressure differenceisdeterminedtobe27%oftheaverageemitterpressure.
The allowable pressure variation in the zone is therefore:

allowable zone pressure variation = allowable pressure differencexoperatingpressure
= 0.27 x 15 psi = 4.0 psi.

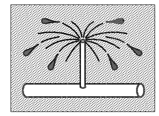
With the information provided above, select a lateral size, calculate the lateral friction loss, the number of laterals per zone, the number of zones, the zone operating time and total system operating time.

Lateral Selection

A single size lateral line is selected therefore the specificdischargerate(SDR)curvescanbe used. In this case there are two emitters located very close to each other on the lateral. To calculate the SDR they can be considered as one discharge point at 9.8 gph, spaced every 10 ft.

(Continued)

Example 7.3 Spray Emitter Lateral Design *(Continued)*



$$\text{Lateral line flow rate} = \frac{\text{lateral line length}}{\text{emitter spacing}} \times \text{emitter flow rate}$$

$$= \frac{400\ \text{ft}}{10\ \text{ft}} \times 9.8\ \text{gph} = 392\ \text{gph}$$

$$\text{SDR} = \frac{\text{lateral flow}}{\text{lateral length}}$$

$$\text{SDR} = \frac{392\ \text{gph}}{400\ \text{ft}} = 0.98\ \text{gph / ft}$$

The pressure variance within the zone must accommodate the elevation difference, lateral friction loss and submain friction loss. To take advantage of the field elevation, the submain should be installed near the top of the field so the laterals do not run uphill very far. Having the submain bisect the lateral will reduce lateral size.

To determine the total allowable friction loss within a zone the pressure gain due to elevation drop can be added to the maximum zone pressure variation while the pressure loss due to elevation gain must be subtracted from the maximum zone pressure variation.

> The pressure variation within the zone must accommodate the elevation difference, lateral friction loss and the submain friction loss. To select an allowable friction loss in the lateral a submain friction loss must first be known. Since this has not yet been calculated start, by using a submain loss of 1.5 psi. The lateral friction loss can then be calculated. The actual submain loss allowed can then be determined by subtracting the lateral friction loss from the allowable zone pressure variation.

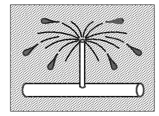
In this instance the submain is to bisect the lateral 100 ft from the top of the field. The lateral length running downhill is therefore 300 ft while 100 ft of lateral is operating uphill. A submain friction loss of 1.5 psi should be allowed for.

The allowable zone friction loss for the 300 ft section running downhill will be:

Elevation gain = 300 x 0.02 = 6 ft = 2.6 psi.
Zone friction loss = 4.0 psi + 2.6 psi = 6.6 psi total friction loss allowed
Lateral friction loss = 6.6 psi - 1.5 psi submain loss = 5.1 psi lateral friction loss allowed
From Figure A.6 – for an SDR of 0.98 gph/ft and a 300 ft row length the lateral friction loss for 20 mm PE is 7.5 ft (3.2 psi). A barb loss of 30% must be added to get the total friction loss.

(Continued)

Example 7.3 Spray Emitter Lateral Design *(Continued)*



Total lateral friction loss = 3.2 psi + (0.30 x 3.2 psi) = 4.2 psi

The 20 mm polyethylene will work for this section since the total lateral friction loss is lower than the total of 5.1 psi that was calculated above.

In summary a 300 ft - 20 mm PE lateral operating two 4.9 gph spray emitters per tree on a 2% downhill slope will have the following pressure variation:

friction loss	= 3.2 psi
emitter barb loss = 0.30 x 3.2 psi	= 1.0 psi
total friction loss	4.2 psi
minus elevation gain	= 2.6 psi
net pressure drop along lateral is	1.6 psi loss

The allowable zone friction loss for the 100 ft section running uphill will be:

Elevation loss	= 100 ft x 0.02 % slope	= 2 ft	= 0.87 psi
Zone friction loss	= 4.0 - 0.90 psi	= 3.1 psi allowable loss	
Lateral friction loss	= 3.1 psi - 1.5 psi submain loss	= 1.6 psi allowable lateral loss	

From Figure A.6 – for an SDR of 0.98 gph/ft and a 100 ft row length the lateral friction loss for 20 mm PE is 1.0 ft (0.43 psi). A barb loss of 30% must be added to get the total friction loss.

Total lateral friction loss = 0.43 psi + (0.30 x 0.43 psi) = 0.56 psi

The 20 mm polyethylene will work for this section as it is within the total of 1.6 psi that was calculated above.

The allowable submain loss for this situation will be:

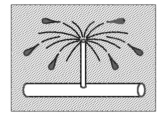
= allowable zone friction loss - lateral friction loss

For the 300 ft section	= 6.6 psi - 4.2 psi	= 2.4 psi
For the 100 ft section	= 3.1 psi - 0.6 psi	= 2.5 psi

The allowable submain loss will therefore be 2.4 psi.

(Continued)

Example 7.3 Spray Emitter Lateral Design *(Continued)*



Number of Laterals per Zone

Water required per row $= \dfrac{392 \text{ gph}}{60 \text{ min /hr}} = 6.5 \text{ gpm}$

Maximum number of laterals per zone:

$$= \frac{\text{source supply}}{\text{water required per row}} = \frac{130 \text{ gpm}}{6.5 \text{ gpm /row}} = 20 \text{ laterals}$$

Number of Zones

The number of zones $= \dfrac{\text{number of rows}}{\text{number of laterals per zone}} = \dfrac{100}{20} = 5 \text{ zones}$

Zone Operating Time

The water is supplied to each plant by two spray emitters operating at 4.9 gph each. The water supplied is therefore 9.8 gph per plant.

Operating time per zone:

$$= \frac{\text{trickle system design requiremen}}{\text{water supplied per plant}} = \frac{40.7 \text{ GPD}}{9.8 \text{ gph}} = 4.15 \text{ hrs /day / zone}$$

Total System Operating Time

Total system operating time = number of zones x operating time per zone

= 5 x 4.15 hrs /day / zone

= 20.75 hours per day during peak conditions

The emitter operating pressure along the lateral will change as lateral friction loss decreases down the lateral. The elevation pressure gain is uniform along the lateral. However, the friction loss will exceed the elevation gain near the beginning of the lateral. Near the end of the lateral elevation gain may exceed the friction loss. The designer must be careful to ensure that the emitter operating pressure range does not exceed the maximum range determined for the emitter type used.

Note:

An example plan of a spray emitter system design is shown in Appendix F (Plan No. 565.015). To make calculations easier a Trickle Irrigation Design Information Sheet is available in Appendix G.

7.4 Submain or Header Layout and Design

A submain or header line is required to distribute water to the lateral lines within a zone. The total pressure variation within a zone will be a sum of the lateral friction loss, submain friction loss and elevation differences. The submain friction loss must therefore be kept at a minimum and be accurately calculated. Points to consider when designing the layout for submain lines are:

- For long crop rows, the submain should bisect the crop row to shorten the lateral line length required. On flat ground the submain will usually bisect the row in the middle.
- The lateral run downhill can be longer than the run up a hill. Therefore on sloping terrain the submain should be located uphill from the centre of the row to allow for shorter lateral runs up the hill and longer lateral runs downhill.
- Where possible the submain should be fed from the centre. This often makes it easier to design the system within the pressure range that is required.
- The submain is installed on the contour whenever possible. If this is not possible care must be taken to ensure that the elevation difference is within the pressure range allowed for the emitter selected. See Section 7.3. Pressure reducers may be required at the laterals if pressure gains are too excessive.

Figure 7.2 indicates the ideal lateral and submain layout from a hydraulic perspective, minimizing friction loss and pipe size. The submain is bisected by the mainline and the laterals bisected by the submain.

An alternate layout is to have the submain feed the laterals from one end as shown in Figure 7.3. This layout is often used where sloping terrain will create significant pressure variations in the lateral to effect emitter emission uniformity. The submain is installed along the top of the field and the laterals run down the hill. Field terrain will often determine the layout that is best suited for the property.

In some instances it may be necessary to feed the submain from one end. The submain should still bisect the lateral whenever possible to keep the lateral sizes as small as possible. It is often more economical to reduce the lateral pipe size first and consider the submain size second. However, if the submain pipe size is too large, the cost of fittings can be expensive, especially if the crop rows are spaced close together. To reduce the cost, a layout similar to Figure 7.4 can be used. Fewer connections are made directly to the PVC submain by utilizing inexpensive polyethylene hose for the majority of connections to the lateral tape. Better pressure control can also be achieved by installing pressure regulators on the supply to each polyethylene subheader. To simplify the drawing, Figure 7.4 shows the laterals being fed from one end.

Figure 7.5 shows details of a manifold connection from the submain to the lateral.

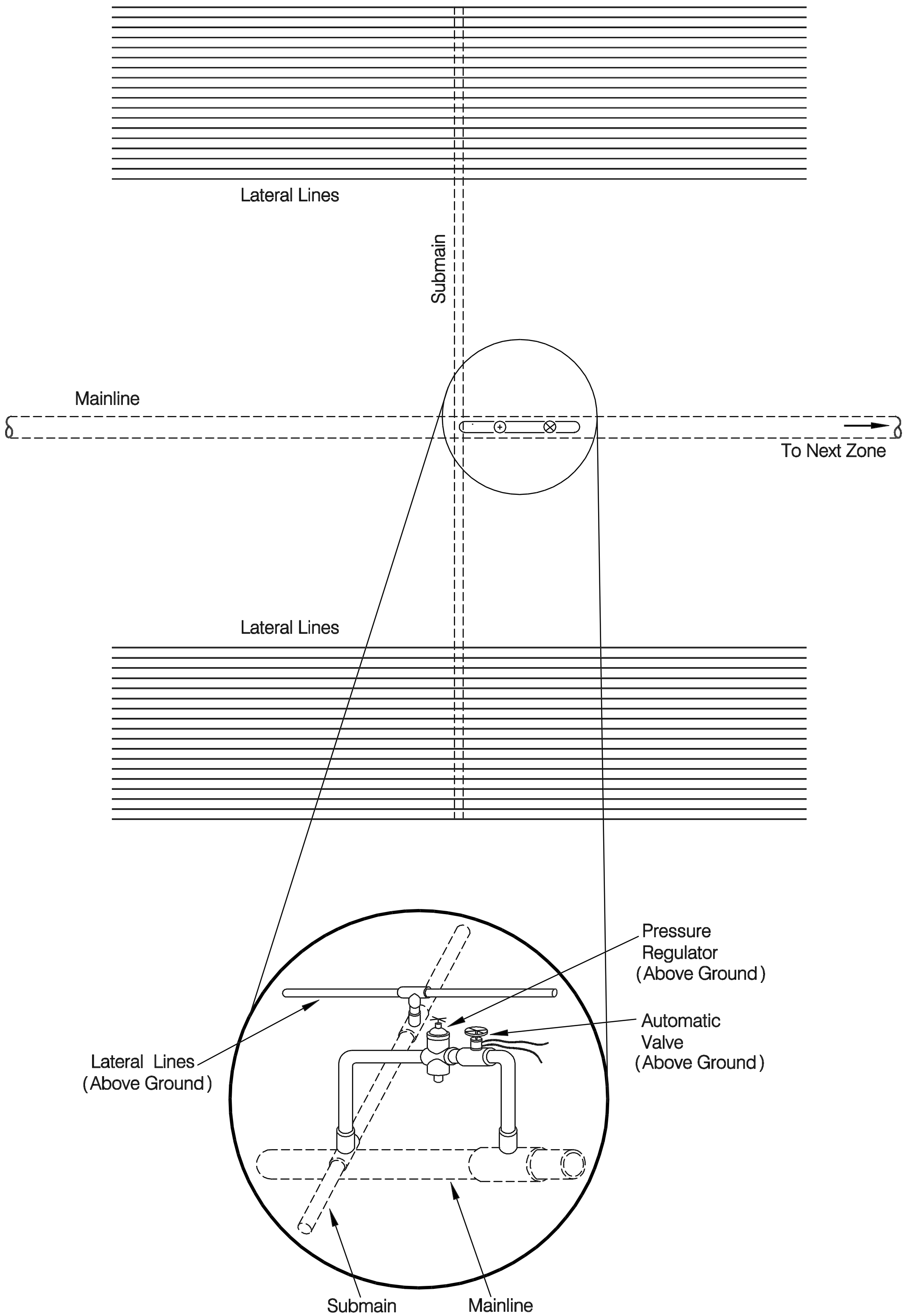


Figure 7.2 *Ideal Submain and Lateral Layout from a Hydraulic Perspective*

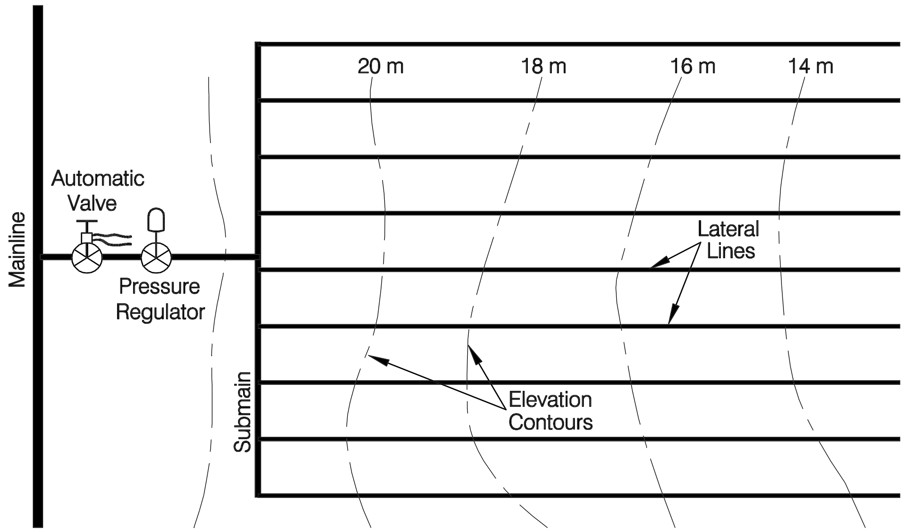


Figure 7.3 *Submain Feeding Lateral from One End*

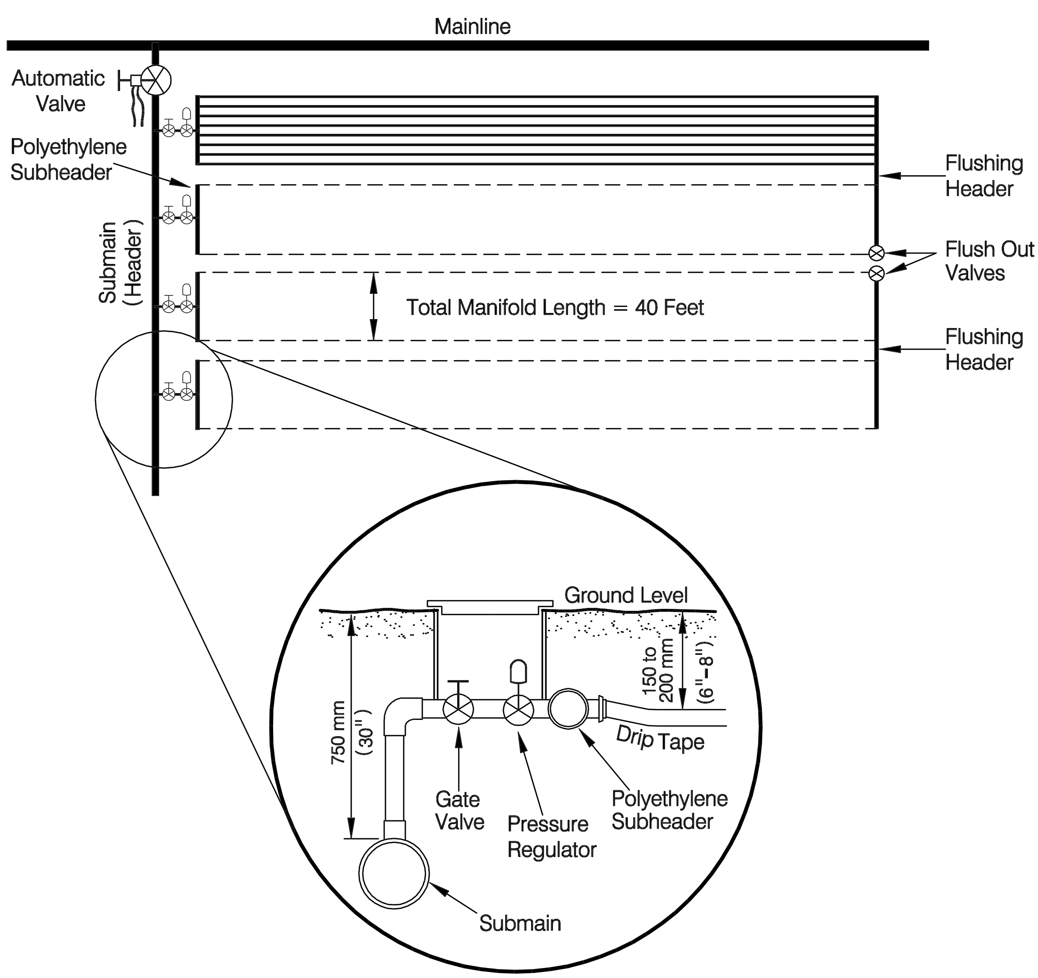


Figure 7.4 *Mainline Feeding Submain from One End*

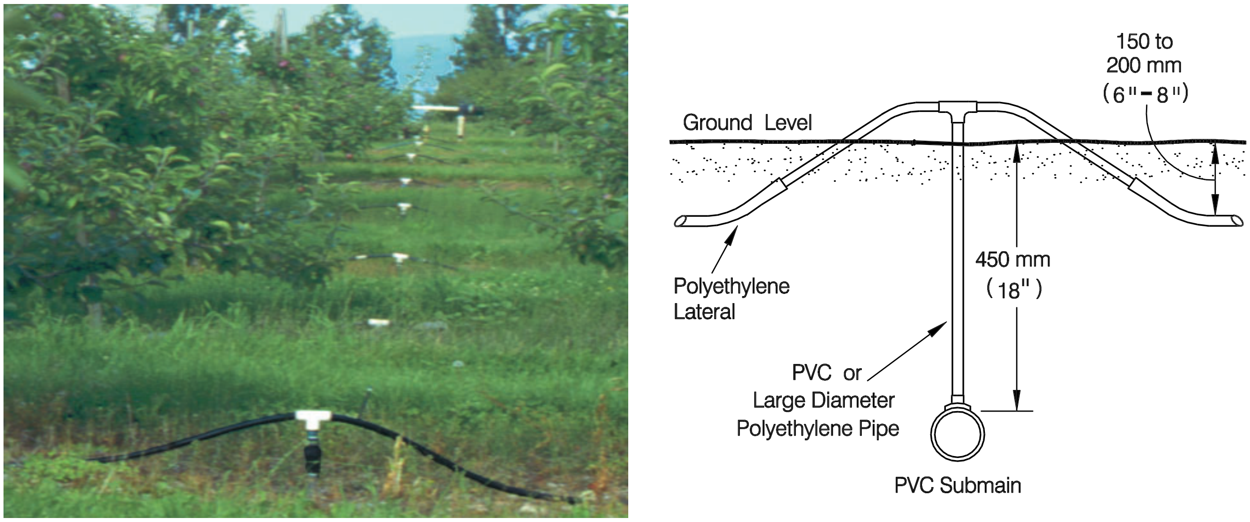


Figure 7.5 *Lateral Connection to a Buried Submain*

Single Size Submain Friction Loss Calculation

Submains that use the same size pipe throughout the entire zone are referred to as single size submains. The friction loss in a single size submain with evenly spaced outlets is a fraction of the friction loss in the same submain with no outlets and the same flow rate. The value of this fraction depends on the number of outlets. Table 7.2 provides the fractional percentage of submain friction loss with numerous outlets.

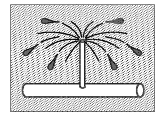
Table 7.2 Submain Friction Loss Factors "F" for Multiple Outlets

Number of Outlets	F	Number of Outlets	F
1	1.0	16	0.365
2	0.625	17	0.363
3	0.518	18	0.361
4	0.469	19	0.360
5	0.440	20	0.359
6	0.421	22	0.357
7	0.408	24	0.355
8	0.398	26	0.353
9	0.391	28	0.351
10	0.385	30	0.350
11	0.380	35	0.347
12	0.376	40	0.345
13	0.373	50	0.343
14	0.370	100	0.338
15	0.367	>100	0.333

From Hardie Design Manual

The most commonly used submain piping materials are PE and PVC. Appendix C provides friction loss charts for the commonly used types and sizes of PE and PVC pipe. Table 7.2 and the friction loss charts in Appendix C can be used in combination to calculate friction loss for single sized submains.

Example 7.4 Single Size Submain Design



The spray emitter lateral specifications determined in Example 7.3 will be used to calculate a single size submain. While there is an elevation change in the direction of the row planting, the topography is flat in the direction of the submain. The trickle system parameters are:

Plant spacing	10 ft x 20 ft
Emitter	each plant has two 4.9 gph spray emitters
Row length	400 ft
Lateral line	20 mm PE
Lateral flow rate	6.5 gpm
Number of laterals per zone	20 laterals
Number of zones	5 zones
Zone flow rate	130 gpm
Zone pressure variation	4.0 psi
Allowable submain loss	2.4 psi (Taking into account lateral friction and elevation)

Using class 160 PVC, determine the submain size and length for the spray emitter system.

The pipe size of the submain can be reduced by having the submain connect to the mainline in the middle of the zone. The allowable submain loss must include pipe friction loss, fitting loss and elevation differences. In this example there are no elevation differences. In many situations there will be elevation differences along both the lateral and submain, and must therefore be accounted for separately.

The fitting loss is approximated by using 20% of the pipe friction loss.

In this case the submain bisects the lateral so that 100 ft of the lateral runs uphill from the submain and 300 ft runs downhill. The submain is fed from the middle of the zone so there are 10 outlets on either side of the connection point.

From the layout described the following submain information can be determined:

Submain length –The critical submain length is the distance from the connection point to the mainline to the lateral at the end of the submain. The entire submain length will be 380 ft from one end of the zone to the other. If connected at the half way point the critical length is 190 ft. The submain layout for this example is similar to the layout shown in Figure 7.2.

Number of outlets – The number of outlets from the connection point to the end of the submain is 10.

Submain Flow Rate –While the flow rate for the zone is 130 gpm, the maximum flow rate in the critical section of the submain will be only half, 65 gpm, as the submain is connected to the mainline in the centre.

(Continued)

Example 7.4 Single Size Submain Design *(Continued)*

The allowable submain loss of 2.4 psi in this example can be separated into 80% for the pipe and 20% for the fittings. As mentioned previously, the fitting losses can be approximated by using 20% of the pipe loss.

Pipe friction loss	= 0.80 x 2.4 psi	= 1.9 psi
Fitting loss	= 0.20 x 2.4 psi	= 0.5 psi
		= 2.4 psi total

From Table 7.2 - for 10 outlets the "fraction factor" = 0.385

The allowable submain pipe friction loss of 1.9 psi for 10 outlets is therefore 38.5% of the pipe friction loss factor for one outlet. To calculate the pipe friction loss allowed:

$$\frac{\text{pipe friction loss}}{\text{submain length x friction factor}} \qquad \frac{1.9 \text{ psi}}{(190 \text{ ft}) \text{ x } (0.385)} = 0.0259 \qquad = \frac{2.59 \text{ psi}}{100 \text{ ft}}$$

Various types of PVC pipe can be used as a submain. Class 125 or class 160 are common for pipe sizes in the 11/2" to 2" range.

From Table C.3 - for a class 160 PVC pipe with a flow rate of 60 gpm and a pipe friction factor of 2.59 psi per 100 ft a 2" submain is required. This is the smallest pipe size that can handle the flow rate required within the friction loss factor calculated.

The above example assumes that the submain feed is fed in the centre. If the submain were to be fed from one end, the submain would be sized for a flow rate of 130 gpm and a pipe friction factor of 2.59 psi/100 ft. Using the information from Table C.3, for a submain fed from one end, a 3" class 160 PVC submain would be required.

It is important that the friction loss tables for the correct pipe type and size are used. If the pipe type used is not shown in this manual, obtain the friction data from the manufacturer.

Multiple Submain Pipe Size Friction Loss Calculation

For longer submains it is often much cheaper to reduce the submain pipe size as the flow decreases. Not only is the pipe cheaper but fitting costs are reduced substantially.

The uniplot method shown in Appendix D can be used to design submains where more than one pipe size is to be used. However, for simple submain designs Table 7.3 can be used to determine submain size. An example illustrating the use of Table 7.3 is given below. The layout of the zone is shown in Figure 7.7.

Example 7.5 Multiple Pipe Size Submain Design

The point source system Example 7.2 will be used to determine a multiple size submain. The topography of the field is flat in this example. The specifications for the system that were determined earlier are:

Plant spacing	5 ft x 12 ft
Emitter	there are two 2L/hr point source emitters per plant
Row length	400 ft
Lateral line	13 mm polyethylene
Lateral flow rate	85 gph or 1.42 gpm / lateral
Number of laterals per zone	75 laterals
Zone flow rate	107 gpm
Allowable submain loss	2.45 psi

Determine the submain pipe sizes required to stay within the allowable pressure loss identified.

In this example, for a 13 mm polyethylene lateral, the submain must bisect the lateral in half to keep the lateral pressure losses acceptable. The submain will be fed from the centre. **The layout is shown in Figure 7.7.** The friction losses shown in Table 7.3 will be used to determine the pipe size required for the submain or header line. The allowable submain friction loss, including fittings, for this example is 2.45 psi.

The fitting friction loss calculations can be simplified by using a percentage of the pipe friction loss. **Normally 25 – 30 % of the pipe friction is used for fittings.** The fitting friction loss can be calculated once the entire pipe friction has been determined or a 25 -30% increase in the pipe length can be used to accommodate the fitting loss. In this example, the row spacing is 12 ft, therefore each section of the submain is also 12 ft. Increasing the length by 25% to accommodate the fitting loss will make the section length 15 ft. The pipe and fitting friction can then be determined right from Table 7.3 using the 15 ft length of line column.

The submain is supplying 75 laterals. Since it is being fed from the centre the submain friction loss needs to be calculated from the centre to the end of the line, supplying 38 laterals one way and 37 the other. To make the use of Table 7.3 easier, the flows for each pipe section can be rounded off to the nearest whole number. A summary of the calculation using Table 7.3 follows.

The summary of calculations for Example 7.3 has five columns.

Column 1 Each section of the submain is identified as shown in Figure 7.7

Column 2 The flow rate in each section of submain increases by 1.42 gpm as this is the flow supplied to each lateral. The total flow rate of the zone is 107 gpm, of which the submain must only carry half (54 gpm).

Column 3 The length of pipe for each section is shown.

Column 4 Identifies the pipe size selected. The pipe size increases as the friction loss for each section exceeds 0.10 psi. This is to stay within the maximum submain friction loss of 2.45 psi.

Column 5 This is the friction loss from Table 7.3 for the pipe size shown in column 4 and the pipe length shown in column 3.

(Continued)

Example 7.5 Multiple Pipe Size Submain Design

(Continued)

Summary of calculations for Example 7.5.

Section	Flow gpm	Length of Pipe ft	Pipe Size inches	Friction Loss psi
1	1.42	7.5	1”	.005
2	2.84	15	1”	.02
3	4.26	15	1”	.03
4	5.68	15	1”	.07
5	7.1	15	1¼”	.03
6	8.52	15	1¼”	.05
7	9.94	15	1¼”	.06
8	11.36	15	1¼”	.07
9	12.78	15	1½”	.05
10	14.2	15	1½”	.06
11	15.62	15	1½”	.07
12	17.04	15	1½”	.08
13	18.46	15	2”	.03
14	19.88	15	2”	.04
15	21.3	15	2”	.04
16	22.72	15	2”	.04
17	24.14	15	2”	.05
18	25.56	15	2”	.06
19	26.98	15	2”	.06
20	28.4	15	2”	.07
21	29.82	15	2”	.08
22	31.24	15	2”	.08
23	32.66	15	2”	.09
24	34.08	15	2”	.10
25	35.5	15	2½”	.04
26	36.92	15	2½”	.05
27	38.34	15	2½”	.05
28	39.76	15	2½”	.06
29	41.18	15	2½”	.06
30	42.6	15	2½”	.07
31	44.02	15	2½”	.07
32	45.44	15	2½”	.07
33	46.86	15	2½”	.08
34	48.28	15	2½”	.08
35	49.7	15	2½”	.09
36	51.12	15	2½”	.09
37	52.54	15	2½”	.10
38	53.96	15	2½”	.10
			Total	**2.39 psi**

The submain friction loss using the pipes sizes shown above is 2.39 psi, which is within the 2.45 psi allowed. The submain will consist of 4 sections of 1” pipe, 4 sections of 1¼” pipe, 4 sections of 1½” pipe, 12 sections of 2” pipe and 14 sections of 2½” pipe.

Figure 7.6 *Submain Installation*

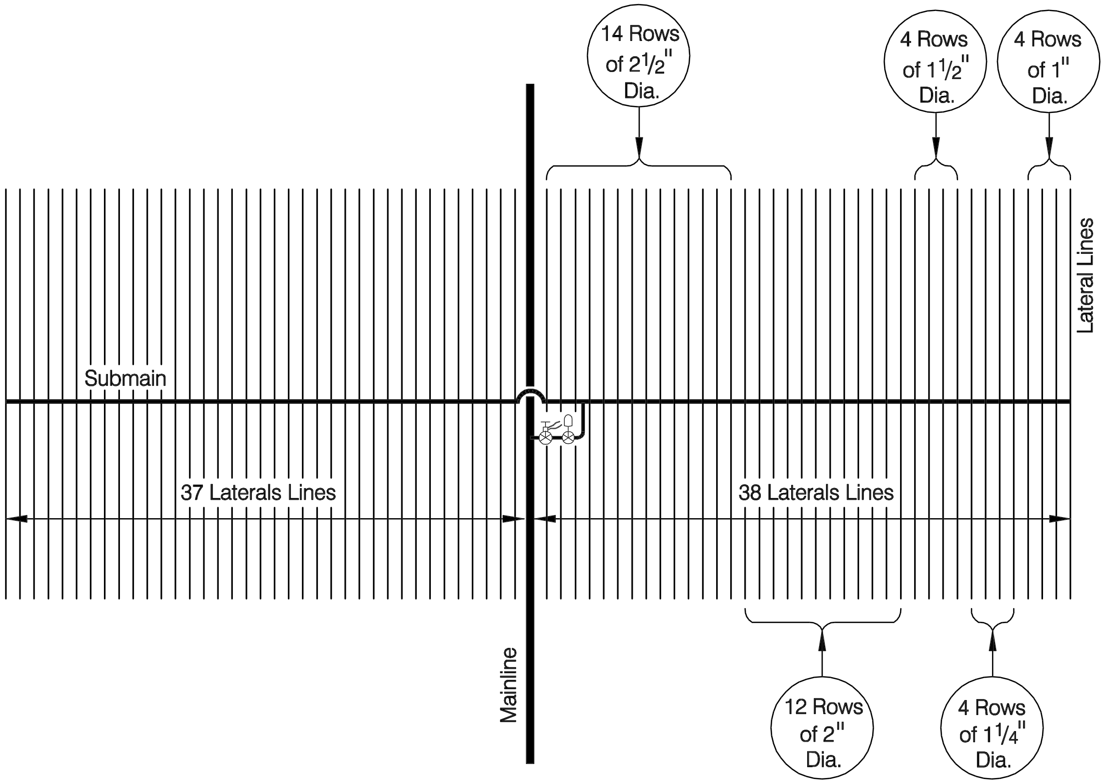


Figure 7.7 *Zone Layout for Multisize Submain (Example 7.5)*

Table 7.3 **Pipe Friction Loss**
(Loss in psi for Class 160 PVC Pipe)

Size (in)	Flow (gpm)	Length of Line (ft.) 5	10	15	20	25	30	40	50
1"	1	.001	.002	.003	.004	.005	.006	.008	.01
	2	.003	.006	.009	.012	.015	.018	.024	.03
	3	.01	.02	.02	.03	.04	.04	.06	.07
	4	.01	.02	.03	.05	.06	.07	.09	.12
	5	.02	.04	.05	.07	.09	.10	.14	.18
	6	.03	.05	.07	.10	.12	.15	.20	.25
	7	.03	.07	.10	.13	.17	.20	.26	.33
	8	.04	.08	.13	.17	.21	.25	.34	.42
	9	.05	.11	.16	.21	.26	.32	.42	.52
	10	.06	.13	.19	.25	.32	.38	.51	.64
	11	.08	.15	.23	.30	.38	.46	.61	.76
	12	.09	.18	.27	.36	.45	.53	.71	.89
	13	.10	.21	.31	.41	.52	.62	.83	1.04
1 1/4"	7	.01	.02	.03	.04	.06	.07	.09	.11
	8	.01	.03	.04	.06	.07	.08	.11	.14
	9	.02	.03	.05	.07	.09	.10	.14	.17
	10	.02	.04	.06	.08	.10	.12	.15	.19
	11	.02	.05	.07	.09	.11	.14	.18	.22
	12	.03	.05	.08	.11	.13	.16	.21	.27
	13	.03	.06	.09	.12	.16	.19	.25	.31
	14	.04	.07	.11	.14	.18	.21	.28	.36
	15	.04	.08	.12	.16	.20	.24	.32	.41
	16	.05	.09	.14	.18	.23	.27	.36	.45
	17	.05	.10	.15	.20	.26	.31	.41	.51
	18	.06	.11	.17	.23	.28	.34	.45	.57
	19	.06	.13	.19	.25	.31	.38	.50	.63
	20	.07	.14	.21	.27	.34	.41	.55	.69
	22	.08	.16	.25	.33	.41	.49	.66	.82
	24	.10	.19	.29	.38	.48	.58	.77	.96
	26	.11	.22	.33	.45	.56	.67	.89	1.12
	28	.13	.26	.38	.51	.64	.77	1.02	1.28
	30	.15	.29	.44	.58	.73	.87	1.16	1.46

Table 7.3 (cont'd)

Pipe Friction Loss
(Loss in psi for Class 160 PVC Pipe)

Size (in)	Flow (gpm)	Length of Line (ft.) 5	10	15	20	25	30	40	50
1 1/2"	10	.01	.02	.03	.04	.06	.07	.09	.11
	12	.02	.03	.05	.06	.08	.09	.12	.15
	14	.02	.04	.06	.07	.09	.11	.15	.19
	16	.02	.05	.07	.09	.12	.14	.19	.24
	18	.03	.06	.09	.12	.15	.17	.23	.29
	20	.04	.07	.11	.14	.18	.21	.28	.36
	22	.04	.09	.13	.17	.21	.26	.34	.43
	24	.05	.10	.15	.20	.25	.30	.40	.50
	26	.06	.12	.17	.23	.29	.35	.46	.58
	28	.07	.13	.20	.26	.33	.40	.53	.66
	30	.08	.15	.23	.30	.38	.45	.60	.75
	32	.09	.17	.26	.34	.43	.51	.68	.85
	34	.10	.19	.29	.38	.48	.57	.76	.95
	36	.11	.21	.32	.42	.53	.63	.85	1.06
	38	.12	.24	.35	.46	.58	.70	.93	1.17
	40	.13	.26	.38	.51	.64	.77	1.02	1.28
	45	.16	.32	.48	.64	.80	.96	1.40	1.60
2"	12	.005	.01	.01	.02	.02	.03	.04	.05
	14	.007	.01	.02	.03	.03	.04	.06	.06
	16	.009	.02	.02	.03	.04	.05	.07	.09
	18	.01	.02	.03	.04	.06	.07	.09	.10
	20	.01	.02	.04	.05	.06	.07	.10	.12
	22	.02	.03	.04	.06	.07	.09	.12	.15
	24	.02	.03	.05	.07	.09	.10	.14	.17
	26	.02	.04	.06	.08	.10	.12	.16	.20
	28	.02	.05	.07	.09	.11	.14	.18	.23
	30	.03	.05	.08	.10	.13	.15	.20	.26
	35	.03	.07	.10	.14	.17	.20	.27	.34
	40	.04	.09	.13	.17	.22	.26	.34	.43
	45	.05	.10	.16	.22	.27	.32	.43	.54
	50	.07	.13	.20	.26	.33	.39	.52	.66
	55	.08	.16	.23	.31	.39	.47	.62	.78
	60	.09	.18	.27	.37	.46	.55	.73	.92

Table 7.3 (cont'd) **Pipe Friction Loss**
(Loss in psi for Class 160 PVC Pipe)

Size	Flow	Length of Line (ft.)							
(in)	(gpm)	5	10	15	20	25	30	40	50
2 1/2"	20	.005	.01	.015	.02	.025	.03	.04	.05
	22	.006	.01	.02	.02	.03	.04	.05	.06
	24	.008	.02	.02	.03	.04	.05	.06	.08
	26	.01	.02	.03	.03	.04	.05	.07	.09
	28	.01	.02	.03	.04	.05	.06	.08	.10
	30	.01	.02	.03	.04	.06	.07	.09	.11
	35	.02	.03	.04	.06	.07	.09	.12	.15
	40	.02	.04	.06	.08	.10	.11	.15	.19
	45	.02	.05	.07	.09	.12	.14	.19	.23
	50	.03	.06	.09	.11	.14	.17	.23	.29
	55	.03	.07	.10	.14	.17	.20	.27	.34
	60	.04	.08	.12	.16	.20	.24	.32	.40
	65	.05	.09	.14	.19	.23	.28	.37	.47
	70	.05	.11	.16	.21	.27	.32	.42	.53
	75	.06	.12	.18	.24	.30	.36	.48	.60
3"	30	.005	.009	.01	.02	.02	.03	.04	.05
	35	.006	.01	.02	.02	.03	.03	.04	.06
	40	.007	.01	.02	.03	.03	.04	.06	.06
	45	.009	.02	.03	.04	.05	.05	.07	.09
	50	.01	.02	.03	.04	.06	.07	.09	.11
	55	.01	.02	.04	.05	.06	.07	.10	.12
	60	.02	.03	.05	.06	.08	.09	.12	.16
	65	.02	.04	.05	.07	.09	.11	.14	.18
	70	.02	.04	.06	08	.10	.12	.16	.20
	75	.02	.05	.07	.09	.12	.14	.18	.23
	80	.03	.05	.08	.10	.13	.16	.21	.26
	85	.03	.06	.09	.12	.15	.18	.24	.30
	90	.03	.07	.10	.13	.16	.20	.26	.32
	95	.04	.07	.11	.14	.18	.22	.29	.36
	100	.04	.08	.12	.16	.20	.24	.32	.40

7.5 Flushing Manifolds

Drip systems usually require line flushing as part of an overall maintenance schedule. For line flushing to be successful sufficient flow must be available to move the material out of the end of the line. For subsurface systems line flushing is very important and is usually done through a common manifold instead of the individual tape lines.

By using a flush valve at the end of the flushing manifold 50 or more lines can be flushed at the same time. The size of both the header and flushing manifold may be dictated by the flushing requirements rather than the irrigation water supply requirement if flushing is done by this method. The flush valve must also be sized correctly to ensure sufficient flow is achieved.

Inlet Pressure

To ensure adequate flushing is achieved the pressure that is required at the zone inlet will depend on:

- The lateral friction loss for the flow that passes through the lateral as flushing water.
- The lateral friction loss for the flow that is discharged through the emitters.
- The pressure required at the flushing manifold including:
  - friction in the flushing manifold
  - friction through the flushout valve
  - elevation change between the end of the lateral and the discharge from the flush valve
  - if the topography is not uniform, changes in elevation along the line may also need to be considered
  - friction loss of fittings

Overcoming the pressure losses in the flushing manifold will require a higher pressure in the lateral line. The higher lateral operating pressure may increase the emitter flow rates which increase lateral friction losses. The pressure at the zone control inlet must then be increased even more. The friction losses for various valves that may be used for flushing are shown in Table 7.4.

Table 7.4 Valve Friction Losses

Flow gpm	Valve Size (nominal in inches) (loss in psi) Gate						Angle						Globe					
	1"	1¼	1½	2	2½	3	1	1¼	1½	2	2½	3	1	1¼	1½	2	2½	3
5	.01						.33	.10	.06	.02	.01		0.6	.20	.11	.04	.02	
10	.05	.02					1.2	.35	.20	.07	.04	.02	2.1	.74	.40	.15	.08	.04
15	.10	.03	.02				2.4	.76	.44	.16	.08	.04		1.6	.90	.30	.16	.07
20	.17	.06	.03	.01			4.4	1.3	.70	.26	.13	.06		2.7	1.5	.53	.27	.12
25	.26	.08	.05	.02				2.0	1.1	.40	.21	.09			2.2	.81	.41	.18
30	.40	.12	.07	.02	.01				1.5	.56	.28	.13				1.2	.57	.25
35	.50	.16	.09	.03	.02					.73	.38	.17				1.5	.76	.33
40		.20	.12	.04	.02					.93	.48	.21				1.9	.97	.42
50		.30	.18	.06	.03	.02				1.4	.73	.32				2.9	1.5	.64
60		.43	.21	.08	.04	.02				2.0	1.0	.50					2.1	.90
70		.60	.25	.11	.05	.02					1.4	.60					2.7	1.2
80		.73	.42	.14	.07	.03					1.8	.77						1.5
90			.47	.18	.09	.04						.95						1.9
100			.64	.22	.11	.05						1.2						2.3
120				.30	.15	.07						1.6						3.2
140				.41	.20	.09						2.2						4.3
160				.53	.25	.11						2.8						5.5

Flushing Flow Rate

To design the size of the flushing manifold and the impacts the manifold will have on the rest of the trickle system a flushing flow rate must be selected. A minimum flow velocity of 1 ft/sec is suggested. Table 7.5 provides the discharge flow rate that is required to achieve a flow velocity of 1 ft /sec at the end of the lateral for various lateral sizes.

Table 7.5 Suggested Lateral Flushing Rates

Lateral Size (Nominal)	Lateral Internal Diameter inches I.D.	Flow Rate (gpm) (Flow Velocity - 1 ft/sec)
10 mm	0.400	0.39
13 mm	0.520	0.66
15 mm	0.600	0.88
16 mm	0.620	0.94
20 mm	0.820	1.65
26 mm	1.05	2.75
3/8 in	0.375	0.34
½ in	0.600	0.88
¾ in	0.820	1.65
1 in	1.05	2.75

Flushing Manifold Design

The flushing manifold only needs to carry the amount of flow that is exiting the lateral line. The flushing manifold should also have a minimum flow rate of 1 ft/sec to be flushed properly. At the same time the pressure loss through the manifold should be kept to a minimum to ensure adequate flushing and cleanout is achieved. The pipe sizes selected should be as small as possible while staying within the friction loss allowable. Table 7.6 provides the flow rate required to achieve a flow velocity of 1 ft/sec for nominal PVC pipe.

If a buried drip system is being flushed with this method, the elevation of the flushing valve above the drip line must also be taken into account. Another method is to install the manifold below ground, providing that an outlet such as a ditch is close by for the manifold to discharge to. See Figure 7.8.

Table 7.6 Flushing Header Pipe Sizes

Nominal Pipe Size PVC	Minimum Flow Rate to Achieve 1 ft/sec (gpm)
½"	1.2
¾"	2
1"	3
1.25"	5
1.5"	6.5
2"	11
2.5"	15

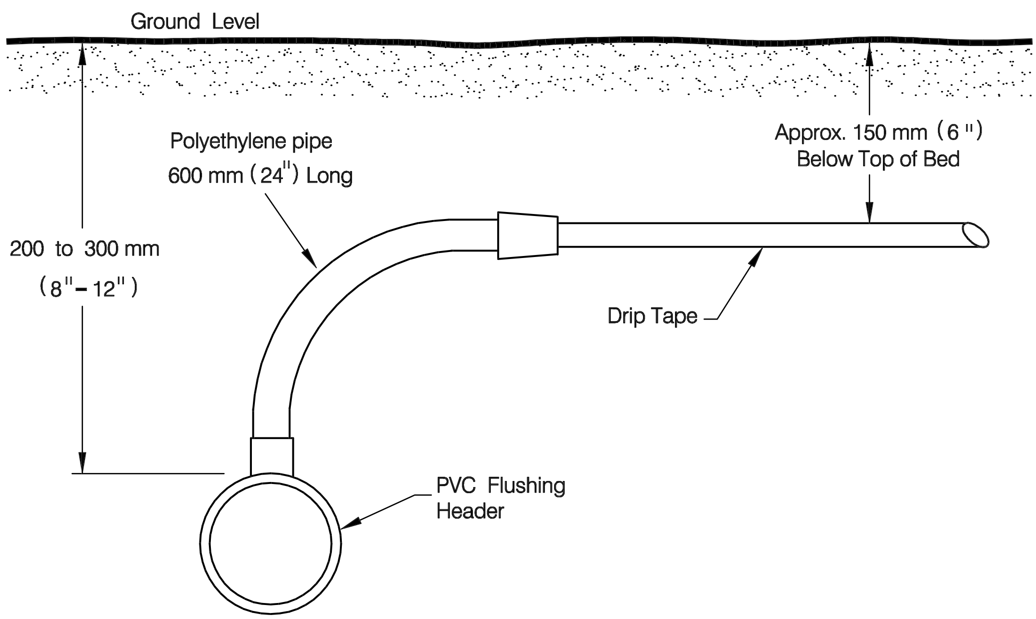


Figure 7.8 *Flushing Header Connection to Laterals*

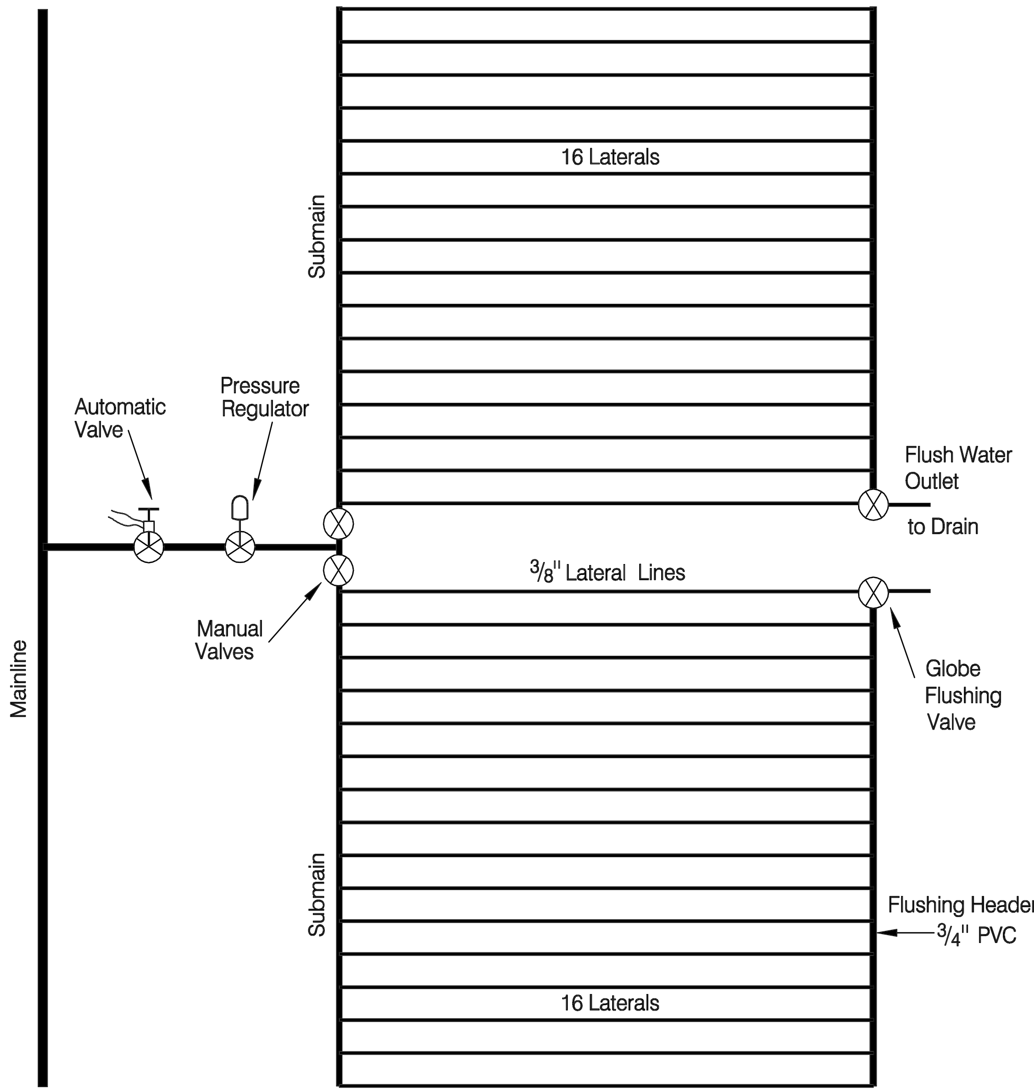


Figure 7.9 *Flushing Header Layout (Example 7.6)*

Example 7.6 Flushing Manifold Design

The linear tape Example 7.1 will be used to design a flushing manifold. The fieldhas a slope in the direction of the lateral but not in the direction of the flushing header. The system parameters are:

hose diameter	3/8” diameter
operating pressure	8 psi is selected
slope	1% downhill
lateral operating pressure	8 psi
lateral flow rate	0.88 gpm / row
rows per zone	32

Select the size of the flushing header, the flush valve size and total system water requirement when flushing is occurring.

From Table 7.5: the flow rate exiting each 3/8” lateral will be 0.34 gpm.

The flushing flow rate for the entire zone will be:

32 laterals x 0.34 gpm = 10.9 gpm

The total zone flow rate while flushing is in progress will include the normal lateral flow, an additional flow from the emitters during flushing and the flow required for flushing. A good rule of thumb is to increase the lateral flow rate by 30% during the flushing mode.

The total flow rate for the zone will be:

Lateral flow rate	= 32 rows @ 0.88 gpm	= 28 gpm
Lateral flow increase while flushing:	= 30% increase = 28 gpm x 0.30	= 8.4 gpm
Flushing requirement		= 10.9 gpm
	Total	= 47.3 gpm

For this example it was established that the well will only be able to supply 30 gpm. The zone must therefore be divided into two sections to be flushed properly. Locating the flushing valves at the mid point of the zone will allow easy access to both flushing valves. See Figure 7.9

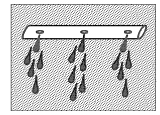
Since there are 32 rows in the zone, dividing the zone in half for flushing will mean 16 laterals are connected to each flushing header. The length of the flushing header will be the row spacing times the number of spaces between the rows. In this case the row spacing is 4 ft and there are 16 spaces between the rows.

16 x 4 ft = 64 ft

A pressure loss of 2 psi is selected for the flushing header, fittings and flushing valve. The flush valve is located at the end of each flushing manifold, near the centre of the zone. See Figure 7.9 for a schematic of the layout.

(Continued)

Example 7.6 Flushing Manifold Design *(Continued)*



The flow rate for each flushing header will be:

16 laterals x 0.34 gpm / lateral = 5.5 gpm

The flushing header friction loss will be determined for a flow of 5.5 gpm. A 1” globe valve will be used for the flushing valve.

From Table 7.4 – Interpolating the chart the friction loss for the 1” globe valve at 5.5 gpm is 0.75 psi.

The friction loss allowable for the header and fittings will be:

2 psi - 0.75 psi = 1.25 psi

As shown in previous sections, the allowable flushing loss of 1.25 psi in this example can be separated into 80% for the pipe and 20% for the fittings.

Pipe friction loss	= 0.80 x 1.25 psi	= 1.00 psi
Fitting loss	= 0.20 x 1.25 psi	= 0.25 psi
		= 1.25 psi total

From Table 7.2 – for 16 outlets the “friction factor” = 0.365

The allowable pipe friction loss of 1.0 psi for 16 outlets is therefore 36.5% of the pipe friction loss factor for one outlet. The pipe friction loss factor for the 64 ft of the flushing header will therefore be:

$$\frac{\text{pipe friction loss}}{\text{submain length x friction factor}} \quad \frac{1.0 \text{ psi}}{(64 \text{ ft}) \times (0.365)} = 0.043 \text{ psi/ft} = \frac{4.3 \text{ psi}}{100 \text{ ft}}$$

From Table C.2 – for a class 160 PVC flushing header with a flow rate of 5.5 gpm and a pipe friction factor of 4.0 psi per 100 ft a ¾” flushing header is required. The actual friction loss of ¾ inch PVC is 1.63 psi / 100 ft at a flow rate of 5.5 gpm.

From Table 7.6 – the minimum flow rate for ¾” PVC to achieve a flow velocity of 1 ft/sec is 2 gpm. Since the flow rate from each lateral into the flushing header is 0.34 gpm it will take 6 laterals before this minimum flow rate is reached. The flow velocity in the flushing header for the first 6 laterals is therefore less than 1 ft/sec. It may be worthwhile considering ½” pipe for this section of the flushing header providing the maximum friction loss is not exceeded. The header friction loss would have to be recalculated. Since the actual friction loss of 1.63 psi/100 ft is much less than 4.3 psi/100 ft allowable the ½” pipe can be used for the first 6 sections.

Considerations for System Flushing

1. When flushing, the inlet pressure must be increased to account for increase in flow creating additional friction loss through the lateral, submain, flushing header pipe, fittings and valves. To accommodate the extra pressure requirement the pressure regulator at the zone inlet must be set higher. Adjustable pressure regulators have an advantage over preset non adjustable regulators for flushing systems.
2. The additional pressure that is required to obtain effective flushing rates can often be 6 to 8 psi. For linear tape systems thicker walled tape may be required to withstand the additional pressure for flushing, even if it may not be required for normal irrigation.
3. The losses through the flushing valve are often more significant than the header line loss. Ensure that the valve selected is large enough.
4. The system delivery rate will need to be oversized in order to supply the flow rate while flushing. Not only may the laterals require more flow due to the higher operating pressures, the line flushing itself will add to the flow rate. As a rule of thumb the lateral flows should be increased by 30% when operated at the flushing pressures. The system must be able to supply the flushing flow rate.
5. Better flushing is usually obtained by flushing only one part of the zone at a time. For small zones dividing the zone in two should be sufficient. Larger zones should be divided into four sections. The flush valves should be situated next to each other for ease of operation.
6. The height of the flushing valve has a significant effect on the flushing