# 專　　論

# Drip Irrigation System Design

# 滴點灌溉系統之設計

美國加州州立 Pomona 大學 (Polytechnic University) 土木及農工系教授
臺北市自來水建設委員會
臺灣省公共工程局顧問
Dr. Yu-tsai Hung
洪　有　才

**中 文 摘 要**

滴點灌溉在近十幾年內不管是在理論或實際應用上具有突飛猛進之趨勢。其系統設計方法有多種但並不統一，不過在基本觀念上則大同小異。筆者擬在此介紹比較新進方法之設計同時加以整理與簡化。本文除將系統設計說明之外，另用設計例使讀者易於了解。

## 1. Introduction

Rather Scientific Drip Irrigation investigations were begun in 1960's in three countries: Chipin in New York,'Hansen in Denmark, and Blass in Israel. The early systems used in those countries were perforated pipes and plastic tubings. Those were specially used in ornamental horticultural industries.

Later on, the technique of drip irrigation has been extended to crops both in row and orchard nature. The irrigated area covered by drip irrigation has grown rapidly in last ten years throughout the world, and various types of emitters have also been invented or modified to cope with different types of field problems. But still, there are lots of problems to be solved, in which clogging is one of the big problems. However, the better understanding regarding the technique of drip irrigation has become increasinaly clear.

To save water is the biggest advantage of the drip irrigation. It also reduces the salt problem because the salt associated capillary water movement would prevent salts from entering the wet envelop around the root zone. The accumulation of salt between root zones may cause salt problem for various type of crops. Nevertheless, this could be overcomed by artificial leaching or leaching through natural rainfall,

water quality and soil condition must be appropriate and the selection of emitters is also critical as far as clogging is concerned. Sometime, filtering system is necessary.

## 2. Design criteria and procedure

prior to design a drip irrigation system, one must gather the following design information.

(1) Water source: available maximum water pressure, available maximum discharge
(2) Soil type: light, midium or heavy

(3) Soil Constants: Field capacity (FC), Permanent wilting point (PWP), Bulk density (As), etc.

(4) Plants: Types, spacing and cultural practices, etc.

(5) Looation, Area, plot map, topographic map, etc.

A simplified design procedure is discussed as follows:

(1) Peak evapotranspiration (T) or consumplive use of water.

The peak evapotranspiration for drip ivrigation design needs to be modified to

$$T = ET \frac{\%\ \text{shade}}{85} \quad \cdots\cdots (1)$$

where ET = peak evapotranspiration for other type of irrigation system design

T = modified peak evapotranspiration for drip irrigation

% shape = depends on the coverage of fully grown tree (or plants) compared with the area occupied by the tree (or plants), usually it ranges from 60% to 80%

(2) Selection of dripper (emitter)

One must try to select an appropriate type of drippers to prevent it from clogging. Ask manufacturer's catalogue and make sure that they have dripper characteristics curves or tables showing the relationship between pressure and discharge.

(3) Spacings and percent of wetness (p)

Once the dripper is selected, follow table 1 and determine the tree spacing and lateral spacing. In determing the lateral spacing, you should choose the percent of wetness equal to 100 between emitters.

For agricultural crops and orchard trees, the the overall percent of wetness must be greater than 33.3. The percent of wetness depends on the discharge of a dripper and the type of soil. It may be affected by the layout arrangement of drippers and laterals (See Fig. 1[(1)]), For single row lateral or one lateral per row, the overall percent of wetness may be found by entering the row spacing on the left column of table I in conjunction with the dripper discharge and the type of soil.

For double laterals, the overall percent of wetness may be computed by

$$P = \frac{P_1 S_1 + P_2 S_2}{S_r} \quad \cdots\cdots (2)$$

where $S_1$ = narrow spacing between pairs of laterals near the tree row while Table I[(1)] shows p=100%

$P_1$ = % of wetners corresponding to $S_1$

$S_2$ = wider spacing between pairs of laterals excluding the tree row

$P_2$ = % of wetness corresponding to $S_2$

$S_r$ = spacing between tree rows.

For muti-exit laterals, overall percent of wetness may be computed by

$$F = \frac{100n\ S_{ep}\ S_w}{S_t\ S_r} \quad \cdots\cdots (3)$$

where n = number of emission points pertree

$S_{ep}$ = the spacing between emission points

$S_w$ = On the left column of Table I[(1)] with 100% wetness between emission points.

$S_t$=spaclng between trees in the rows

$S_r$=spacing between tree rows

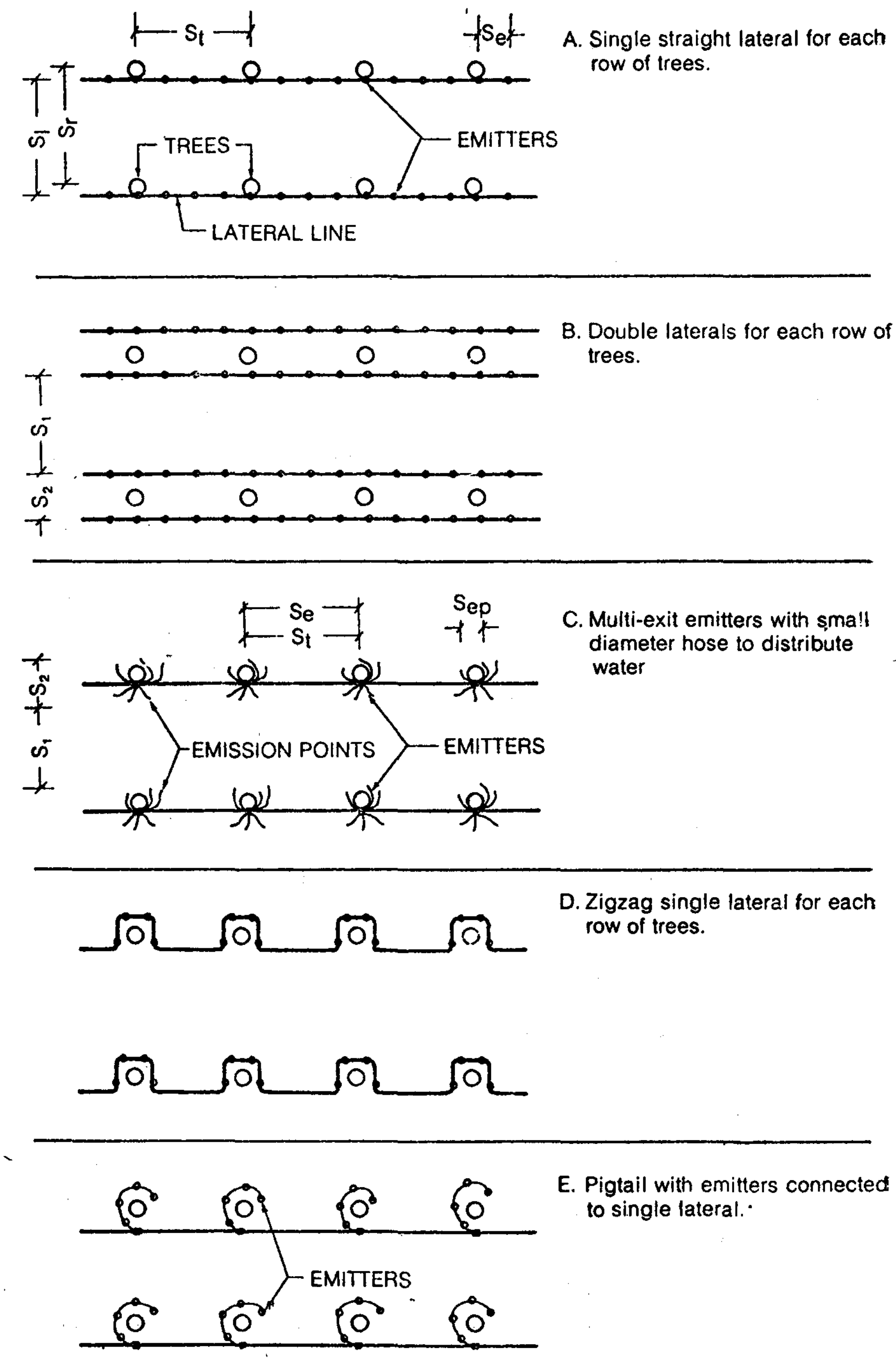



*Figure 1 Common patterns for placing lateral lines to irrigate orchards.*

Table I. Percentage of soil wetted by various discharges and spacings for a singlerow of uniformly spaced emission points in a s.right line applying 40 mm (1.6 in) of water per cycle over the wetted area.

| Effective Spacing Between Laterals | Emission-Point Discharge[2] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | less than 1.5 lph (0.4 gph) | | | 2 lph (0.5 gph) | | | 4 lph (1 gph) | | | 8lph (2 gph) | | | more than 12 lph (3 gph) | | |
| | Recommended Spacing of Emission Points Along the Lateral for Coarse, Medium, and Find Textured Soils Se, m (ft)[3] | | | | | | | | | | | | | | |
| S/[1] | C | M | F | C | M | F | C | M | F | C | M | F | C | M | F |
| m (ft) | 0.2 (0.7) | 0.5 (1.7) | 0.9 (3.0) | 0.3 (1.0) | 0.7 (2.3) | 1.0 (3.3) | 0.6 (2.0) | 1.0 (3.3) | 1.3 (4.3) | 1.0 (3.3) | 1.3 (4.3) | 1.7 (5.6) | 1.3 (4.3) | 1.6 (5.3) | 2.0 (6.6) |
| | Percentage of Soil Wetted[4] | | | | | | | | | | | | | | |
| 0. (2.6) | 38 | 88 | 100 | 50 | 100 | 100 | 100 | 100 | 100 | 100 | 109 | 100 | 100 | 100 | 100 |
| 1.0 (3.3) | 33 | 70 | 100 | 40 | 80 | 100 | 80 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1.2 (3.9) | 25 | 58 | 92 | 33 | 67 | 100 | 67 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1.5 (4.9) | 20 | 47 | 73 | 26 | 53 | 80 | 53 | 80 | 100 | 80 | 100 | 100 | 100 | 100 | 100 |
| 2.0 (6.6) | 15 | 35 | 55 | 20 | 40 | 60 | 40 | 60 | 80 | 60 | 80 | 100 | 80 | 100 | 100 |
| 2.5 (8.2) | 12 | 28 | 44 | 16 | 32 | 48 | 32 | 48 | 64 | 48 | 64 | 80 | 64 | 80 | 100 |
| 3.0 (9.8) | 10 | 23 | 37 | 13 | 26 | 40 | 26 | 40 | 53 | 40 | 53 | 67 | 53 | 67 | 80 |
| 3.5(11.5) | 9 | 20 | 31 | 11 | 23 | 34 | 23 | 34 | 46 | 34 | 46 | 57 | 46 | 57 | 68 |
| 4.0(13.1) | 8 | 18 | 28 | 10 | 20 | 30 | 20 | 30 | 40 | 30 | 40 | 50 | 40 | 50 | 60 |
| 4.5(14.8) | 7 | 16 | 24 | 9 | 18 | 26 | 18 | 26 | 36 | 26 | 36 | 44 | 36 | 44 | 53 |
| 5.0(16.4) | 6 | 14 | 22 | 8 | 16 | 24 | 16 | 24 | 32 | 24 | 32 | 40 | 32 | 40 | 48 |
| 6.0(19.7) | 5 | 12 | 18 | 7 | 14 | 20 | 14 | 20 | 27 | 20 | 27 | 34 | 27 | 34 | 40 |

1. Where double laterals (or laterals having multi-exit emitters) are used in orchards, enter with the average lateral spacing as S/ provided the spacing between any two laterals (or rows of emission pionts) is equal to or greater than an S/ value which would give p=100%.
2. When irrigation is applied in relatively short pulses, the horizontal spread of the wetted zone is less than for heavier applications. Therefore, the table should be entered with an effective emission point discharge of approximately haif the instantaneous discharge. in soils with hard pans, clay or sand lenses, or other stratifications which enhance the horizontal spread of molsture the table may be entered with up to double the installationrate for regular application (or for the instantaneous rate for short pauses).
3. The texture of the soil is designated by C. coarse; M, medium; M, medium; and F, fine. The emission point spacing is equal to approximately 80% of the largest diameter of thc wetted area of the soil underlying the point. (Gloser spacings on the lateral do not affect the percentage area wetted.)
4. The percentage of soil wetted is qased on the area of the horizontal section approximately 0.30m (1.0ft) beneath the soil surface. in wide spaced tree crops caution should be exercised where less than 1/3 of the soil volume will be wetted in low rainfall areas or 1/5 in high rainfall areas. In close spaced crops most of the soil volume may need to be wetted to assure a sufficient water supply to each plant.

(4) Computing maximum net depth of irrigafion ($I_{dx}$)

you may use

$I_{dx}=y\ (FC-PWP)ZP/100$ ······(4)

where Y =allowable depletion of soil moisture in fraction. The rule of thumb for Y=0.3.

Z =rooting depth

P =overall percent of wetness (must be greater than 33.3%)

(5) Maximum irrigation interval allowed ($I_{im}$)

$$I_{1m} = \frac{I_{dx}}{T} \qquad (5)$$

(6) Adjusted total net depth of water per irrigation ($I_{dn}$)

$$I_{dn} = T\ I_{1m} \qquad (6)$$

(7) Gross depth of water needed per irrigation ($I_d$)

$$I_d = \frac{100 I_{dn}}{TR \times EU} \qquad (7)$$

wher TR = irrigation application efficiency in fraction ($\geq 0.9$)

Eu = Emission uniformity ($\geq 90\%$)

(8) water to be purchased per irrigation (V)

$$V = I_d \times Area$$

(9) Duration per irrigation (or time of watering per irrigation) per set ($I_t$)

$$I_t = K \frac{I_d\ S_e\ S_l}{q_a}\ (hr) \qquad (8)$$

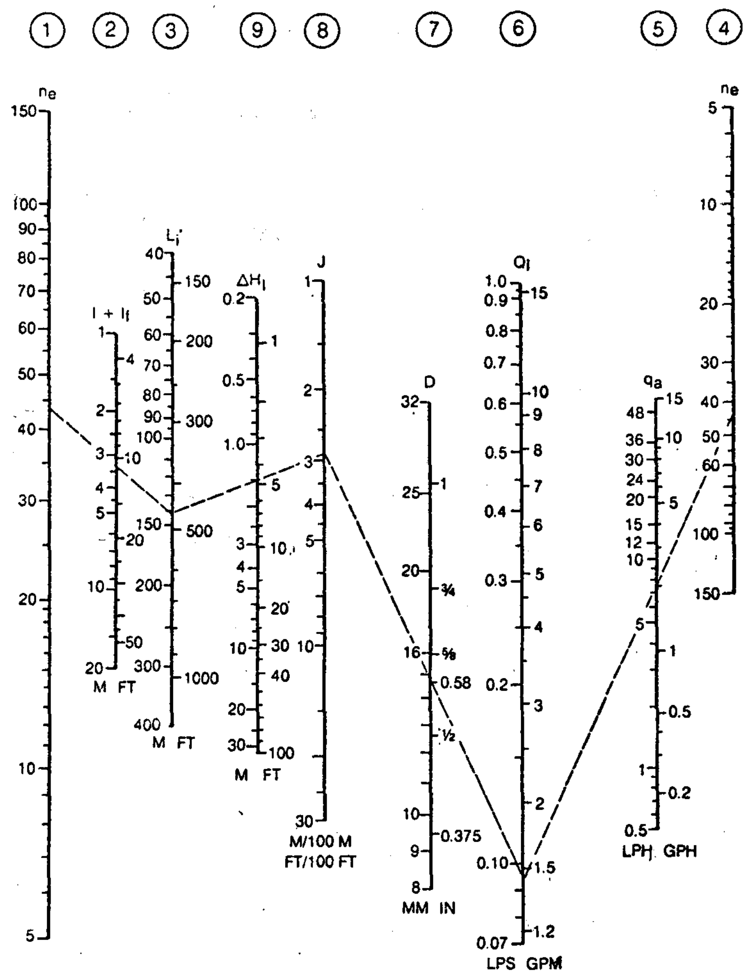



*Figure 2* *The lateral head loss nomograph for various inside diameters of hose having a coefficient of roughness, C = 150, and using the equivalent length concept to compensate for emitter connection losses.*

where K=conversion factor, for English System K=0.623

$S_e$=dripper spacing (ft)

$S_\ell$=lateral spacing (ft)

$q_a$=dripper discharge (ft)

(10) Maximum operation unit (or set) per time (N)

$$N > \frac{I_i \times 24}{I_t} \qquad (9)$$

where $I_i$=adjusted irrigation interval (days)

(11) Total duration for entire area ($t_T$)

$$t_T = \frac{I_t}{N} \times N \qquad (10)$$

(12) Lateral discharge ($Q_a$)

Add all emitter discharges on the lateral line.

(13) Manifold discharge ($Q_m$)

Add all lateral discharges on the manifold.

(14) Main line discharge (Q)

Add all manifold discharges which are operated by the main line at a time.

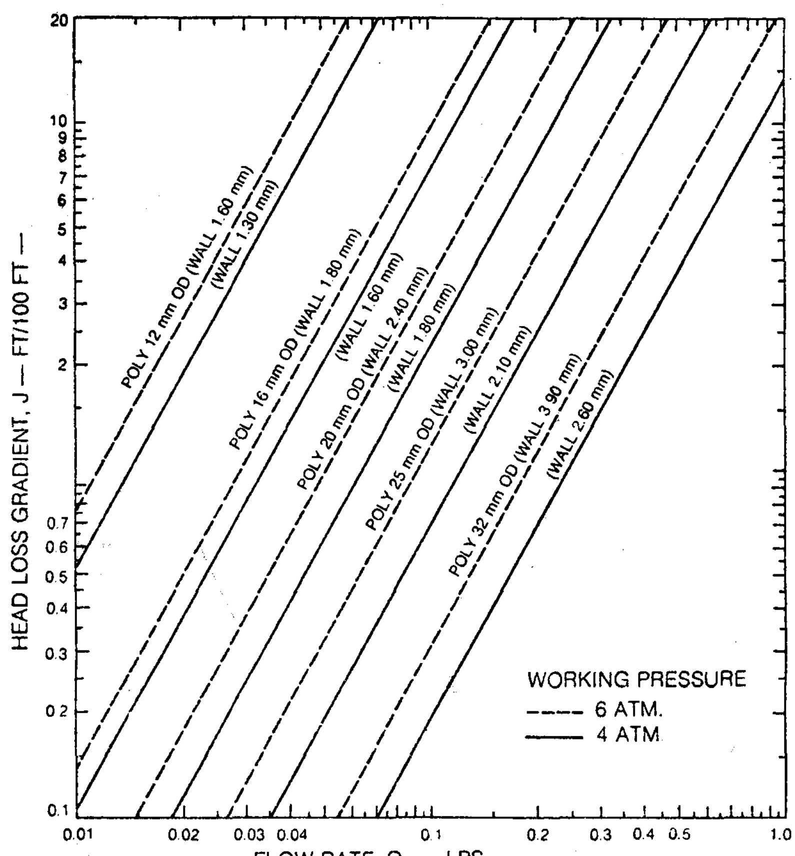



*Figure 3* *Head loss for various outside diameters of soft polyethylene hose used in trickle irrigation laterals.* C = 150.

(15) Friction loss in the lateral line ($\Delta H_l$)

May use Fig 2, or equation

$$\Delta H_l = J\, n_e(\ell+\ell_f)F/100 \quad \text{(11)}$$

where $n_e$ = the number emitters on of the lateral (or out lets)

$\ell$ = the length of pipe between emitters

$\ell_f$ = the equivalent added length of pipe which is equal to the friction loss caused by the lateral flow past each emitter

J = the head loss gradient, may be found by Fig. 3. or Fig. 4[1]

$$F = \frac{\sum_{I=1}^{ne} I^{1.85}}{n_e^{2.85}} \quad \text{(12)}$$

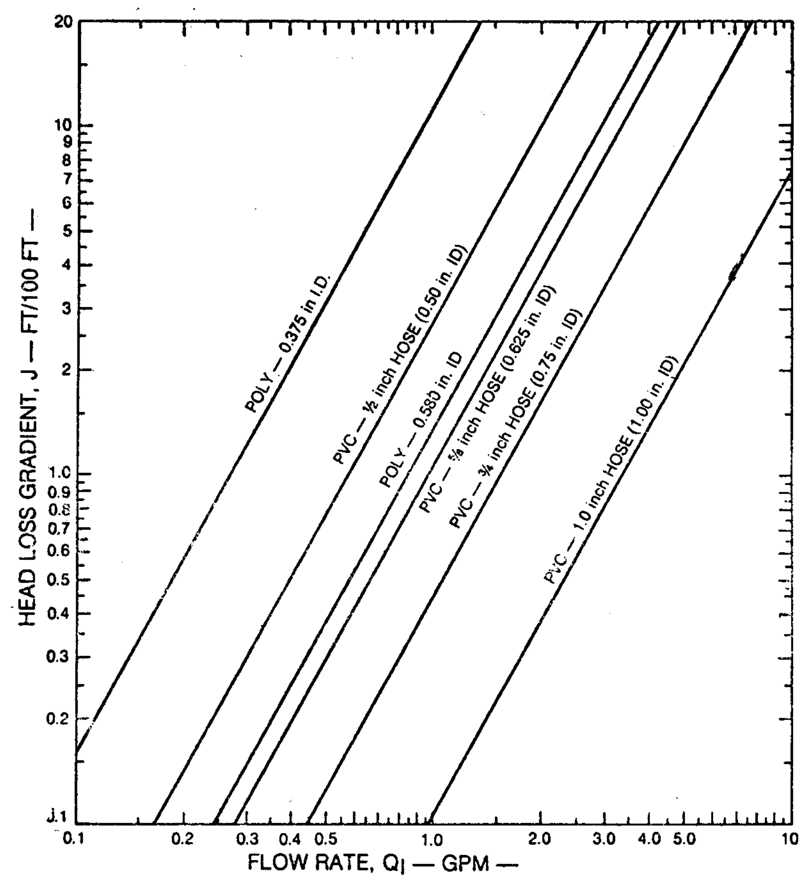



**Figure 4** *Head loss for various available inside diameters of soft polyethylene hose and soft PVC used in trickle irrigation laterals. C = 150.*

or see Table II.

(16) Friction loss in the manifold ($\Delta H_m$) may be found by

$$\Delta H_m = \frac{J\, L_m\, F}{100} \quad \text{(13)}$$

Table II. Reduction coefficient F to use in Ep.'s 11, 13 for multiple outlet lines.

| Outlets $n_e$ | Value F | Outlets $n_e$ | Value F | Outlets $n_e$ | Value F |
|---|---|---|---|---|---|
| 1 | 1.000 | 8 | 0.415 | 20 | 0.376 |
| 2 | 0.639 | 10 | 0.402 | 25 | 0.371 |
| 3 | 0.535 | 12 | 0.394 | 30 | 0.368 |
| 4 | 0.486 | 14 | 0.387 | 40 | 0.364 |
| 5 | 0.457 | 16 | 0.382 | 50 | 0.361 |
| 6 | 0.435 | 18 | 0.379 | 100 | 0.536 |

Where J = the head loss gradient, may be found by Fig. 5. or Fig. 6[1]

$L_m$ = manifold length

F = same as above, but you must change $n_e$ to the number of outlets.

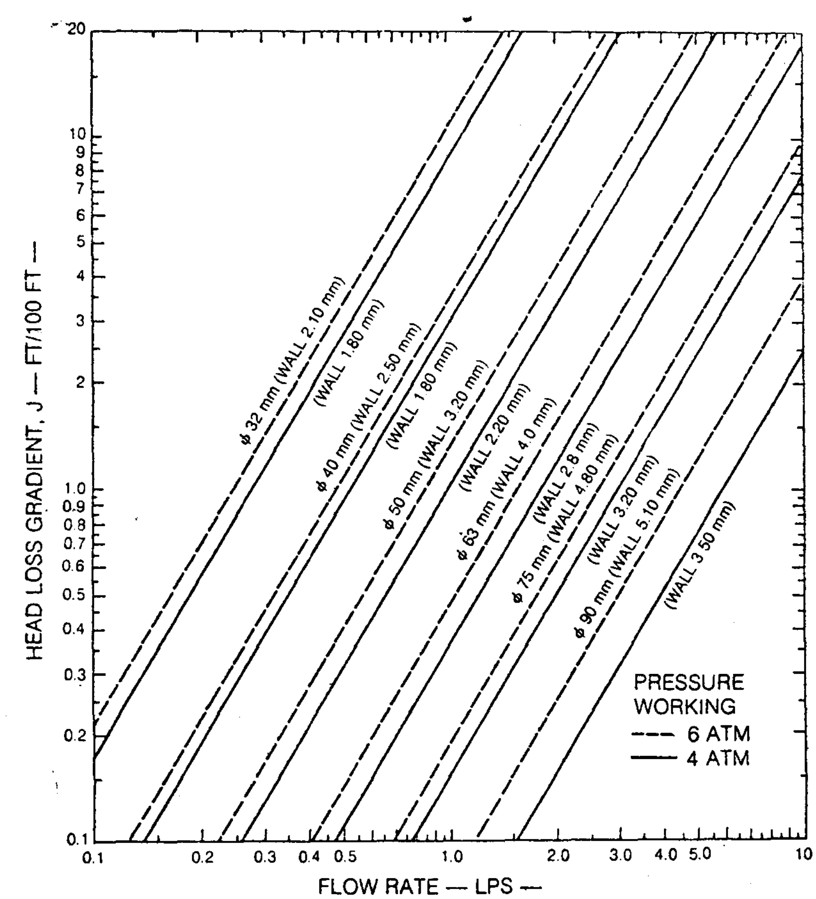



Figure 5 *Head loss in rigid polyethylene pipe of various outside diameters commonly used for trickle irrigation system manifolds and mainlines. C = 150.*

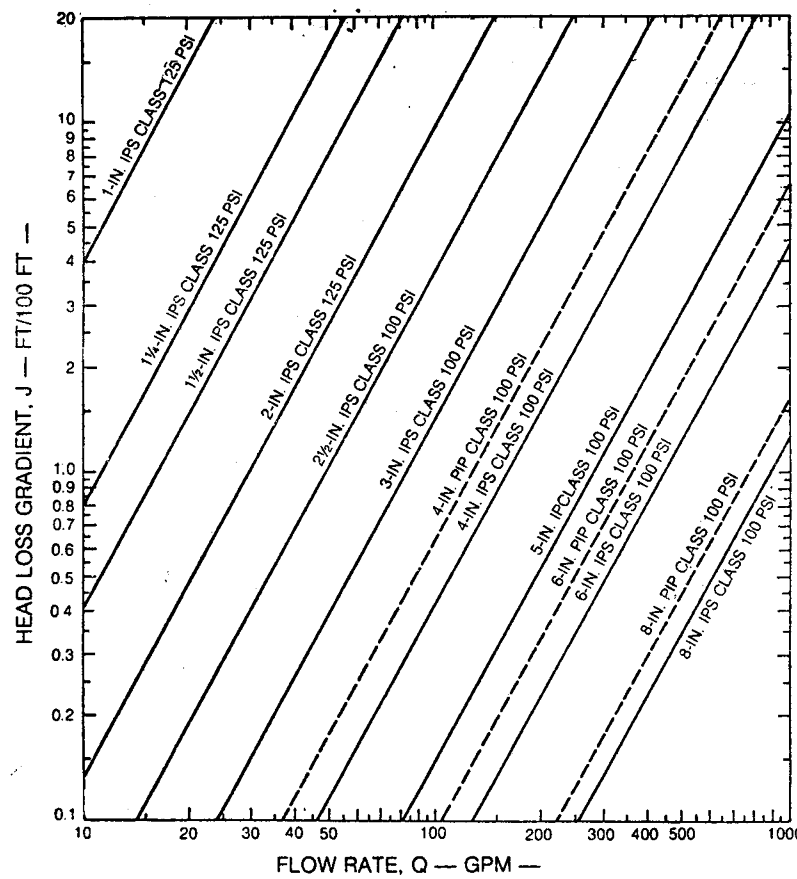



**Figure 6** *Head loss in rigid PVC pipe of various designated diameters and classes (operating pressure ratings in psi) used for trickle irrigation system manifolds and mainlines. C = 150. (IPS means iron pipe size outside diameter and PIP means plastic irrigation pipe.)*

(17) Friction loss in the mainline (ΔH)

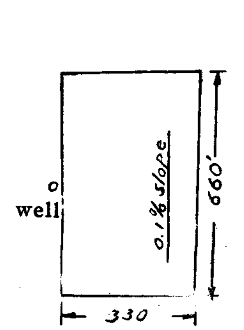
To find loss of head through the mainline, use the some procedure as outlined in the manifold friction loss computations.

(18) Others may refer to any books in sprinkler irrigation design

## 3. Design Example

Given: 1. Water source: Max. pressure=40 psi
Max. discharge=400 gpm

2. Soil: Medium texture
3. Plants: Pumpkins; 5-ft×5-ft spacing
4. Soil constants: FC=30% , PWP=15% by weight, $A_s$=1.3
5. Location: Pomona, California
6. Total area: 5-ac (660′×330′)
7. Plot map:



## Deigsn Procedure:

1. Peak evapotranspiration (or consumptive use of water)

$$T = ET \times \frac{\%\ shade}{85}$$

% shade = 70 (assumed)

ET = 0.25 in/day (peak for melons, intermountain, desert, california)

$$T = 0.25 \frac{in}{day} \times \frac{70}{85} = 0.206\ in/day$$

2. Selection of emitters and determination of spacings

Try Anjac bi-wall; 36″×144″ emitter spacing (See the attached sheet). This means that the opening spacing of the outside wall is 36″, and the inner wall opening spacing is 144″.

From the table, try lateral length of 165′, and perssure at 30 psi, then from the table,

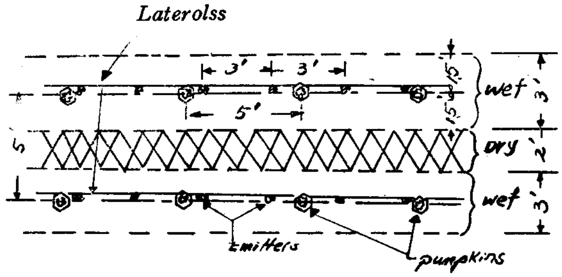
| Length of Run | GPM/Lateral |
|---|---|
| 150′ | 0.54 |
| 200′ | 0.72 |

The interpolated discharge for 165′ lateral should be equal to 0.54 gpm plus 0.054 gpm or 0.594 gpm/lateral.

From 36″=3′ spacing, the number of emitters per lateral is 165′ divided by 3′/emitter=55 emitters. Therefore, the average discharge per emitter is

$$\frac{0.594 \frac{gal}{min} \times 60 \frac{min}{hr}}{55\ emitter} = 0.65\ gph/emitter$$

The emitter apacing 36″ is supposed to give 100% wetness between emitters. Try one lateral per row of pumpkins and the lateral is laid by the pumpkin plants. See the following arrangement:




3. Computing the percent of wetness (p)

From Table I P=80% (Greater than 33%, O. K.)

Other types of lateral arrangement should see equations 2 and 3.

4. Computiug maximum net depth of irrigation (or maximum depth of water to be depleted)

$I_{dx} = y(FC - PWP)\ ZP/100$

where: Z=3′ (Rooting depth for melon)

p=80%(From above)

y=0.3 (or 30%, rule thumb)

$(FC-PWP)=(30-15)\%=15\%$ by weight

$=15\%\times A_s=15\%\times 1.3=19.5\%$ by volume

Therefore, (FC−PWP) in inches of water is equal to

$$\frac{19.5\times 1\ ft\times 12in/ft}{100}=2.34in/ft$$

$$I_{dx}=0.3\times 2.34\frac{in}{ft}\times 3\ ft\times 80/100=1.685\ in$$

5. Maximum irrigation interval allowed ($I_{dn}=I_{dx}$)

$I_{im}=I_{dx}/T=1.685$ in/(0.206 in/day) $=8.179$ days Say 8 days$=I_i$

6. Adjusted total net depth of water per irrigation

$$I_{dn}=T\ I_{im}=0.206\frac{in}{day}\times\ 8\ days=1.648\ in$$

7. Gross depth of water needed per irrigation ($I_d$)

$$I_d=\frac{100\ I_{dn}}{TR\times EU}=\frac{100\times 1.685\ in}{90\times 90}=2.08\ in$$

Assume 0.9 and 90% for TR and EU respectively.

8. Water to be purchased per irrigatiion (volume)

$I_d\times Area=2.08\ in\times 5\ ac=10.40\ ac-in.$

9. Duration per irrigation (or time of watering per irrigation) per set

$$I_t=K\frac{I_d\ S_e\ S_l}{q_a}=0.623\times\frac{2.08\ in\times 3\ ft\times ft}{0.65\ gph}=29.9\ hrs./set$$

10. Maxmum operation units (or sets)·········N

$$N\leq\frac{I_i\times 24}{I_t}=\frac{6\times 24\ hr}{29.9\ hrs}=4.81$$

Say, 4 units.

11. Total duration for the entire area

$$t_T=\frac{time}{set}\times sets=\frac{29.9\ hr}{set}\times\ 4\ sets=119.6\ hrs.$$

If it is irrigated continuously (24 hrs/day), then the total days of watering the entire area is

$$\frac{119.6\ hrs}{24\ hrs/day}=4.98\ days$$ (Smaller or shorter than 8 days, OK)

12. Lateral discharge ($Q_a$)·········See the following layout (Fig. 7)

55 emitters per 165-ft lateral

$Q_a=2\ N_e q_a=2\times 55\times 0.65$ gph

$=53.95$ gph$=0.9$ gpm. or called $Q_l$

13. Manifold discharge ($Q_m$)

The N-S plot length is 660′. There are 4 sets. Therefore the length of each manifold is 660′/4=165′.

Because the lateral spacing is 5-ft, there are 165 ft/5 ft=33 laterals in each set.

$Q_m=0.9$ gpm$\times 33=29.7$ gpm/manifold

14. Mainline discharge (Q)

Same as $Q_m$ in this case.

15. Friction loss in the lateral

Using Fig. 2 or equation 11. For this case, the given conditions don't fit Fig. 2.

We use equation 11.

$$\Delta H_1 = Jn_e(\ell+\ell_f)F/100$$

Say, using $D=\frac{1}{2}''$ PE with $Q_1=0.9$ gpm. We found $J=2.0$ from Fig. 4.

Emitter lateral contains more than 20 ontlets, use $F=0.37$ (See Table II).

Lateral length=165', and $n_e=55$. $\ell=3'$ (emitter spacing)

$\ell_f=0$ (Because the Anjac bi-wall emitters practically give no friction loss in the bi-wall)

$$\Delta H_1 = 2\times55\times3\times0.37/100 = 1.22'$$

16. Friction loss in the manifold

Say, using 2" IPS class 100 psi, Fig. 6 with $Q_m=29.7$ gpm, we found $J=1.0$. Manifold length=660'/4=165' F-value may be found from Table II, which is 0.358.

Therefore the loss of head in the manifold is

$$H_m = \frac{J\ L_m\ F}{100} = \frac{1.0\times165\times0.358}{100} = 0.59'$$

17. Friction in mainline

Apply the same method as used in the manifold.

18. Others See sprinkler irrigation design.

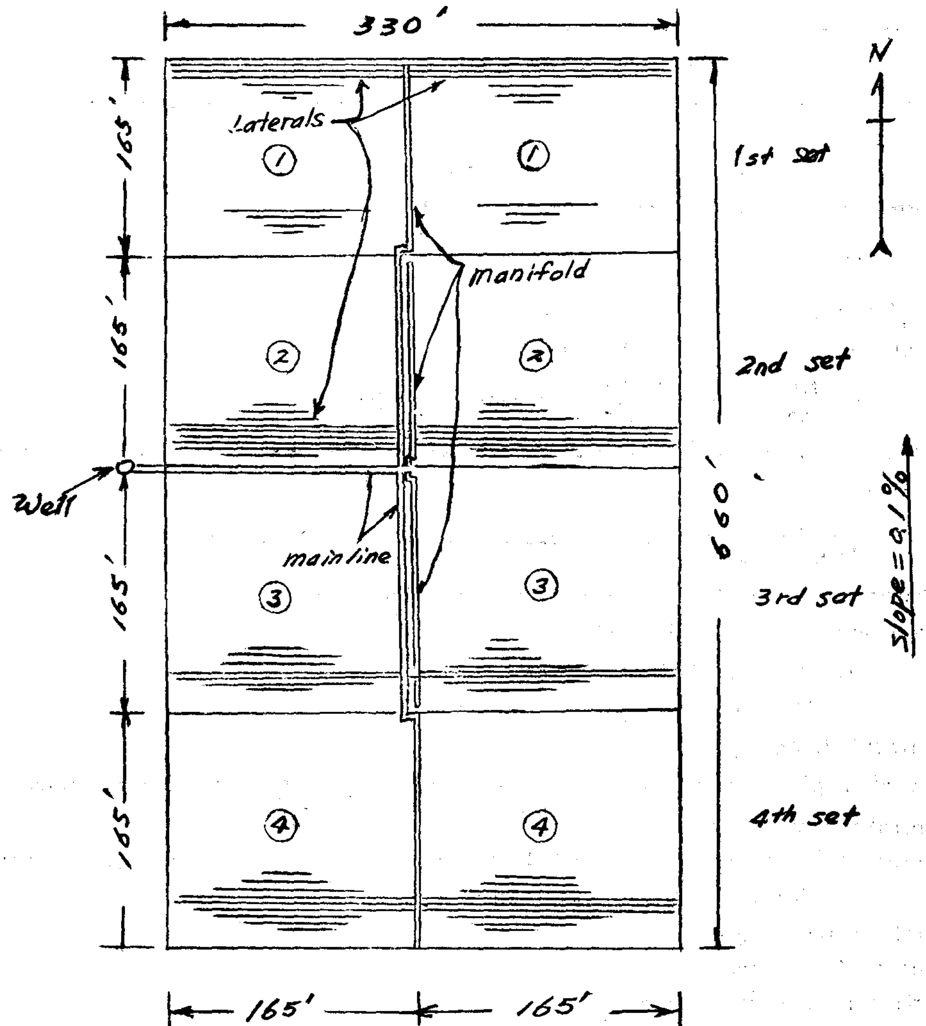



圖 7 設計例圖

Table III[3]

## ANJAC BI-WALL FLOW CHARTS

### 12"×60" Emitter Spacing

| Length of Run | GALLONS PER MINUTE | | | | | |
|---|---|---|---|---|---|---|
| | 5 PSI | 10 PSI | 15 PSI | 20 PSI | 25 PSI | 30 PSI |
| 100′ | .44 | .61 | .75 | .88 | .96 | 1.07 |
| 150′ | .66 | .92 | 1.12 | 1.32 | 1.43 | 1.60 |
| 200′ | .88 | 1.22 | 1.49 | 1.76 | 1.91 | 2.14 |
| 250′ | 1.10 | 1.53 | 1.87 | 2.20 | 2.39 | 2.68 |
| 300′ | 1.32 | 1.84 | 2.24 | 2.64 | 2.86 | 3.21 |
| 350′ | 1.54 | 2.14 | 2.61 | 3.08 | 3.34 | 3.74 |
| 400′ | 1.76 | 2.45 | 2.99 | 3.52 | 3.62 | 4.28 |
| 450′ | 1.98 | 2.75 | 3.36 | 3.96 | 4.30 | 4.82 |
| 500′ | 2.20 | 3.06 | 3.74 | 4.40 | 4.78 | 5.35 |
| 550′ | 2.42 | 3.37 | 4.11 | 4.84 | 5.25 | 5.88 |
| 600′ | 2.64 | 3.67 | 4.48 | 5.29 | 5.73 | 6.42 |
| 650′ | 2.86 | 3.98 | 4.86 | 5.73 | 6.21 | 6.96 |
| 700′ | 3.08 | 4.28 | 5.23 | 6.17 | 6.68 | 7.49 |

### 18"×72" Emitter Spacing

| Length of Run | GALLONS PER MINUTE | | | | | |
|---|---|---|---|---|---|---|
| | 5 PSI | 10 PSI | 15 PSI | 20 PSI | 25 PSI | 30 PSI |
| 100′ | .29 | .41 | .50 | .58 | .64 | .71 |
| 150′ | .44 | .61 | .75 | .87 | .96 | 1.07 |
| 200′ | .58 | .82 | 1.00 | 1.16 | 1.29 | 1.42 |
| 250′ | .72 | 1.02 | 1.25 | 1.45 | 1.61 | 1.78 |
| 300′ | .87 | 1.22 | 1.50 | 1.74 | 1.93 | 2.14 |
| 350′ | 1.02 | 1.43 | 1.75 | 2.03 | 2.25 | 2.49 |
| 409′ | 1.16 | 1.63 | 2.00 | 2.32 | 2.57 | 2.85 |
| 450′ | 1.30 | 1.84 | 2.25 | 2.61 | 2.89 | 3.20 |
| 500′ | 1.45 | 2.04 | 2.50 | 2.90 | 3.22 | 3.56 |
| 550′ | 1.60 | 2.24 | 2.75 | 3.19 | 3.54 | 3 92 |
| 600′ | 1.74 | 2.45 | 3.00 | 3.48 | 3.86 | 4.27 |
| 650′ | 1.88 | 2.65 | 3.25 | 3.77 | 4.18 | 4.63 |
| 700′ | 2.03 | 2.86 | 3 50 | 4.06 | 4.50 | 4.98 |

Table III Continued

ANJAC BI-WALL FLOW CHARTS

24″×96″ Emitter Spacing

| Length of Run | GALLONS PER MINUTE | | | | | |
|---|---|---|---|---|---|---|
| | 5 PSI | 10 PSI | 15 PSI | 20 PSI | 25 PSI | 30 PSI |
| 100′ | .22 | .30 | .38 | .43 | .48 | .53 |
| 150′ | .33 | .46 | .56 | .65 | .73 | .80 |
| 200′ | .45 | .61 | .75 | .86 | .97 | 1.06 |
| 250′ | .56 | .76 | .94 | 1.08 | 1.21 | 1.33 |
| 300′ | .67 | .91 | 1.12 | 1.30 | 1.45 | 1.60 |
| 350′ | .78 | 1.06 | 1.31 | 1.51 | 1 69 | 1.86 |
| 400′ | .89 | 1.22 | 1.50 | 1.73 | 1.94 | 2.13 |
| 450′ | 1.00 | 1.37 | 1.69 | 1.94 | 2.18 | 2.39 |
| 500′ | 1.12 | 1.52 | 1.88 | 2.16 | 2.42 | 2.66 |
| 550′ | 1.23 | 1.67 | 2.06 | 2.38 | 2.66 | 2.93 |
| 600′ | 1.34 | 1.82 | 2.25 | 2.59 | 2.90 | 3.19 |
| 650′ | 1.45 | 1.98 | 2.44 | 2.81 | 3.15 | 3.46 |
| 700′ | 1.56 | 2.13 | 2.62 | 3.02 | 3.39 | 3.72 |

36″×144″ Emitter Spacing

| Length of Run | GALLONS PER MINUTE | | | | | |
|---|---|---|---|---|---|---|
| | 5 PSI | 10 PSI | 15 PSI | 20 PSI | 25 PSI | 30 TSI |
| 100′ | .15 | .20 | .25 | .29 | .31 | .36 |
| 150′ | .22 | .30 | .37 | .43 | .47 | .54 |
| 200′ | .29 | .40 | .49 | .57 | .63 | .72 |
| 250′ | ·37 | .50 | .62 | .71 | .78 | .90 |
| 300′ | .44 | .60 | .74 | .86 | .94 | 1.08 |
| 350′ | .51 | .70 | .86 | 1.00 | 1.10 | 1.26 |
| 400′ | .59 | .80 | .99 | 1.14 | 1.26 | 1.44 |
| 450′ | .66 | .90 | 1.11 | 1.28 | 1.41 | 1.62 |
| 500′ | .74 | 1.00 | 1.24 | 1.42 | 1.57 | 1.80 |
| 550′ | .81 | 1.10 | 1.36 | 1.57 | 1.73 | 1.98 |
| 600′ | .88 | 1.20 | 1.48 | 1.71 | 1.88 | 2.17 |
| 650′ | .96 | 1.30 | 1.60 | 1.85 | 2.04 | 2.35 |
| 700′ | 1.03 | 1.40 | 1.73 | 2.00 | 2.20 | 2.53 |

jj
4-9-75

4. Reference

1. Trickle Irrigation Design: Jack Keller and Karmeli D. Published by Rainbird Sprinkler Manufacturing Corporation: Glendora, California 91740 U. S. A. 1975.

2. Drip Irrigation Catalog: Anjac Plastics Division, Reed Irrigation Systems Baldwin El Monte, California 91731 U. S. A. 1976.