CHAPTER 17: Low-cost pipes distribution system

INTRODUCTION

Pump irrigation covers the majority of the irrigated lands in the developing countries of the arid and semi-arid regions. The irrigation water taken from the aquifer or the surface run off ponds, lakes, rivers and dams, is pumped to the fields through conventional (earth) ditches or lined canals, resulting into tremendous losses from seepage and evaporation, deep percolation and canal leakage.

Studies from many countries show an average of 33 percent water losses during conveyance through a 100 m conventional channel. The field irrigation methods are the traditional surface gravity - furrow, basin, border etc., with field application efficiencies of 60–70 percent, i.e. additional water losses of about 20–27 percent of the total. Then the overall irrigation efficiency ranges from 40 pecent to 47 percent approximately.

The solution to the problem is the closed pipes improved irrigation techniques. The huge gap between the water wasteful open surface irrigation practices and the highly efficient improved irrigation techniques

FIGURE 17.1 - Irrigating young trees with the PDS.

can be eliminated with the implementation of the Pipe Distribution Irrigation System (PDS). This irrigation technique had been extensively applied in Cyprus in the early sixties and in Yemen (Tihama) in early eighties with big success. It is actually the replacement of the open channels with a properly designed closed piping network to convey and distribute the irrigation water up to the field plots without any losses. It is a simple technology with the minimum cost, which in one night may raise the overall irrigation efficiency from 40 percent up to 77 percent. The PDS is a closed pipe surface irrigation technique and it is classified as a low-medium pressure system with solid permanent installation (Figure 17.1).

SYSTEM LAYOUT AND COMPONENTS

The basic layout of the PDS consists of a simple control head, a pipe distribution network and the hydrants.

The ***control head*** includes the necessary regulating valves (shut off, check valve, air valve) placed on a piece of galvanized steel threaded pipe, 60 cm above ground surface, with tee outlet for taps and pressure gauge. This arrangement, at a later stage, can easily be converted to a more sophisticated control unit, suitable for micro-irrigation systems.

The ***main and sub-main pipelines*** (distribution network) can be of rigid PVC, 90–160 mm DN, 4–6 Bars PN, buried underground. On hilly areas other kind of pipes are used on surface ground, such as the flexible black Polyethylene (HDPE), the Quick Coupler light steel or the galvanized steel threaded pipes. The latter is used only up to the 3 in size, because of the high cost.

The ***hydrants*** are rising on surface equipped wit a shut off valve (gate valve) capable to deliver part of the systems flow or the whole of it to the manifold open ditches. At a later stage portable lightweight pipes (quick couplers aluminum, light steel, lay-flat hose, black polyethylene, etc.) can be attached to the hydrants, replacing the manifold open ditches, for the final delivery. From the hydrants the irrigation water is discharged directly to the manifold open earth channels for diversion to the furrows, the basins or the strip borders.

DESIGN CRITERIA AND CONSIDERATIONS

The pipes distribution system combines both the features of the open surface methods and the pressurized closed pipe techniques. The design criteria and the parameters are too many as compared to the simplicity of the installation (Figure 17.2). The topography of the area (shape, slope, etc.), the type of soil, the size of flow and the method of water delivery to

the crop (furrow, basin, border or other) should be carefully examined. The take-off hydrants must be placed at the highest points of the field plots and at the right distances to enable efficient practices of the gravity irrigation techniques through the manifold ditches.

"The most important criterion to be considered during the design is the possibility for future extension of the network for the adoption of any other low-medium improved irrigation system, such as sprinkling, drip, spitters, etc., with the minimum expenses. Then the careful design of a flexible skeleton-piping network, suitable to serve all methods of irrigation and water delivery techniques is of major importance".

FIGURE 17.2 - Installation of the pipes.

In this kind of installations the size of the pipes is not reduced at the secondary and tertiary branches (sub-mains, etc.), but remains the same all along the network (Figure 17.3). Thus the system is capable to deliver its total flow at any point of the farm, through each separate hydrant. This results into some extra cost for the pipes. There are no limitations on the kind of the pipes and fittings to be used, apart from the dimensions and the working pressures. The diameter (DN) of the pipes of the network depends on the size of water flow and the flow velocity that should be in the range of 1.4 m/s to 2.0 m/s (Table 17.1). The pipes working pressure (PN) must be around 6.0 Bars and in any case not less than 4.0 Bars. For the determination of the pipe diameter the flow velocity formula Q = AV is used in the form:

$$Q\ (l/h) = V\ (m/s) \times 2{,}826\ di^2\ mm$$

where, **Q** the system flow, **V** the selected flow velocity (usually taken 1.7 m/s), **di** the pipe internal diameter. Based on the above, the recommended flow for various kinds and sizes of pipes are as follows:

TABLE 17.1 - Flow versus pipe diameter

V = 1.7 m/s²	Galvanized steel threaded, light series			Rigid PVC, 6.0 bars			HDPE, 6.0 bars	
DN mm	2 in	2 ½ in	3 in	90	110	160	90	110
di mm	54	69	82	84.4	103.2	150.2	79	97
Flow m³/h	14	23	32	34	51	108	30	45

COST

This system is a low-medium pressure with solid permanent installation. The initial cost per unit of area is lower as compared with the other closed pipes pressurized irrigation systems. The average cost per ha is around 850 US dollars. In the following example design the cost is US$900 per ha. Also the fuel consumption is lower than in any other improved irrigation system. Only the labor expenses are relatively high. This technique is classified as low-cost irrigation technology.

ADVANTAGES

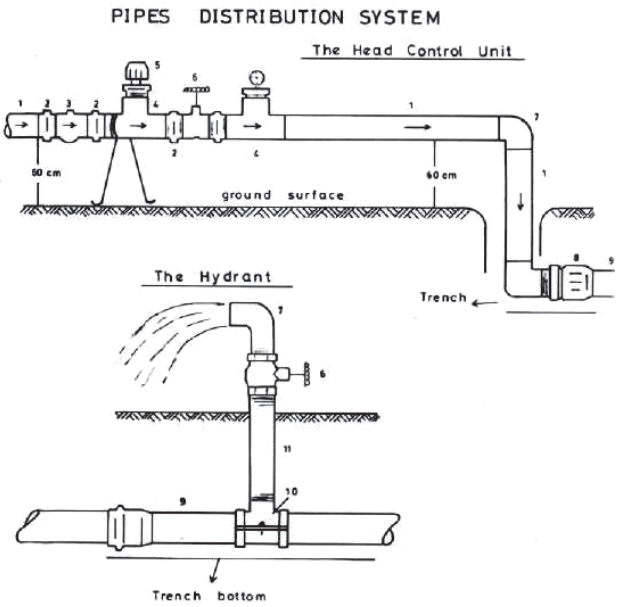
- Low initial capital investment
- Availability of equipment
- Easy to operate and maintain
- High adaptability by the farmers
- Suitable for a wide range of crops
- Appropriate for all sizes of holdings and plot irregular shapes

DISADVANTAGES

- Requires skilled irrigator
- Low field application (delivery) efficiency
- In unleveled fields and sandy soils is not easily adapted
- Not applicable for small flows
- Best suited for medium-heavy soils

Despite the above mentioned advantages and disadvantages the main characteristic of this system is that this is the first step to be taken to facilitate the farmers to change from the traditional irrigation practices to the more advanced ones smoothly, safe and with the least expenses (Figure 17.4).

FIGURE 17.3 - The PDS Control Head and the Hydrant.



EXAMPLE DESIGN

Area and crop

The design area is 3.3 ha approximately, divided into six field-plots of the same rectangular shape and dimensions, 90 *x* 45 m. The crop can be citrus, cotton, vegetables, melons, potatoes, alfalfa, or any other seasonal or perennial one. The topography is smooth and there is a slope of around 0.4–0.6 percent from north to south and east to west (see map).

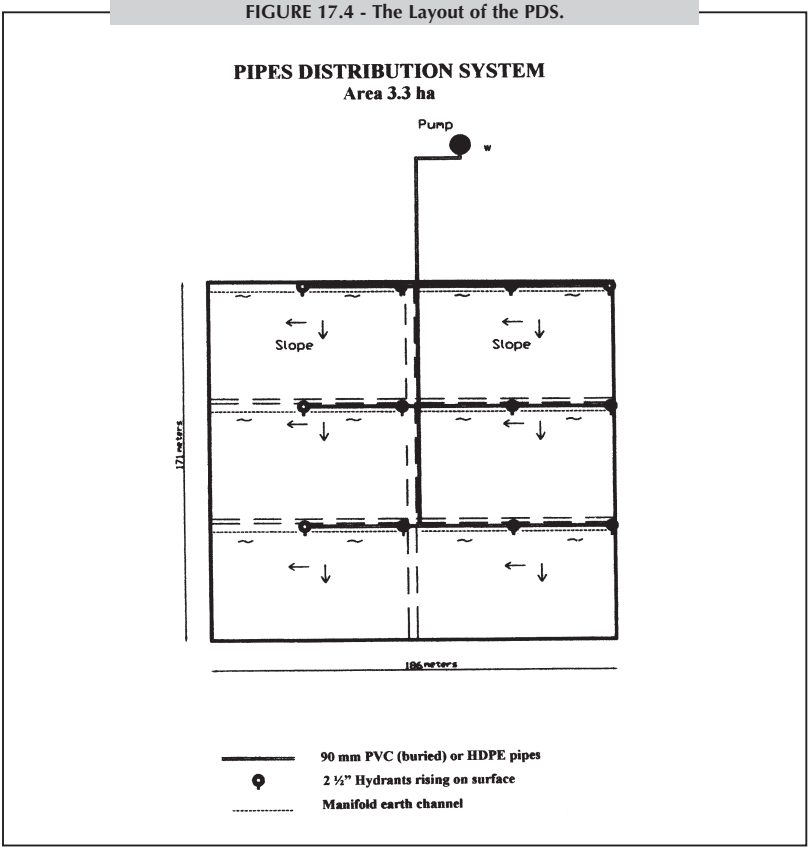
Soil and water

The soil is of medium texture and of good structure with moderate infiltration rate and internal drainage. **Sa** is around 150mm/m depth. The water is good quality with no toxicity or sodium hazards. It is a pumped from a nearby tube-well at a rate of 27 m^3/hour (7.5 l/s) for 12 hours per day.

Water requirements and irrigation scheduling

The estimate of the irrigation needs and the schedule depends upon the climatic data and the kind of crop to be irrigated. However, the water availability that is 324 m^3/day (27 m^3/h *x* 12 hours) corresponds to a daily

FIGURE 17.4 - The Layout of the PDS.



application of 9.8 mm in an area of 3.3 ha. This amount of water can meet the demands of any crop at peak.

The system layout and dynamic head

There is a conveyance pipeline, 100 m approx., from the pump to the farm gate. It is made of rigid PVC 90 mm, 6.0 Bars. The on-farm piping distribution network, of the same kind and size, is placed along the borderlines of the field plots. All pipes are buried. Take off hydrants 2 in are raising on surface, each one serving an area of 0.27 ha. The system's dynamic head for normal operation is the pipeline loss of head due to friction, plus the losses in the control head and the local minor losses, minus the difference in elevation, all included 0.9 Bars (Figure 17.5 and Table 17.2).

TABLE 17.2 - List of equipment needed for the Pipe Distribution System Installation (Bill of quantities). ***Area: 3.3 ha, System flow: 27 m³/h, Dynamic head: 0.9 Bars. 0.9 Bars.***

Item	Description	Quantity	Unit price US$	Total price US$
	System distribution network			
1.	90 mm rigid PVC pipe, 6.0 bars	660 m	2.50	1650.00
2.	2 ½ in x 90 mm PP male adaptor	1 pc	10.00	10.00
3.	90 mm PP elbow	1 pc	15.00	15.00
4.	90 mm PP tee	5 pcs	22.00	110.00
5.	90 mm x 2 ½ in PP female tee	6 pcs	19.00	114.00
6.	90 mm x 2 ½ in PP female elbow	6 pcs	13.50	81.00
7.	2 ½ in threaded riser pipe 60 cm	12 pcs	5.00	60.00
8.	2 ½ in brass gate valve	12 pcs	14.00	168.00
9.	2 ½ in elbows threaded male	12 pcs	3.00	36.00
10.	Trench excavation and backfilling	660 m	1.00	660.00
	Sub-total			**2904.00**
	Head control			
11.	2 ½ in brass check valve	1 pc	16.00	16.00
12.	2 ½ in brass gate valve	1 pc	14.00	14.00
13.	2 ½ in tee threaded female	2 pcs	3.50	7.00
14.	2 ½ in nipple	2 pcs	1.00	2.00
15.	2 ½ in pipe threaded 60 cm	2 pcs	5.00	10.00
16.	2 ½ in elbows threaded female	1 pc	3.00	3.00
17.	1 in single air valve	1 pc	12.00	12.00
18.	Pressure gauge w/adaptor base 2 ½ in	1 pc	14.00	14.00
	Sub-total			**78.00**
	TOTAL COST			**2982.00**