



## Bubbler irrigation design

The typical landscape irrigation system has a set of valves that activate different irrigation zones in the landscape. It is best to divide trees and shrubs into different zones (figure 1). Tree water requirements are so much greater than shrub requirements that it is nearly impossible to water them in the same zone. When trees and shrubs are in the same zone, shrubs are often given so much water that roots rot. In addition, it is best to divide high water use, medium water use, and low water use plants into different zones. Some plants lose foliage in winter while others continue to use water and require winter irrigation in the desert. If the plants are on the same zone, then it is impossible to meet the variable water requirements of the different plant types.

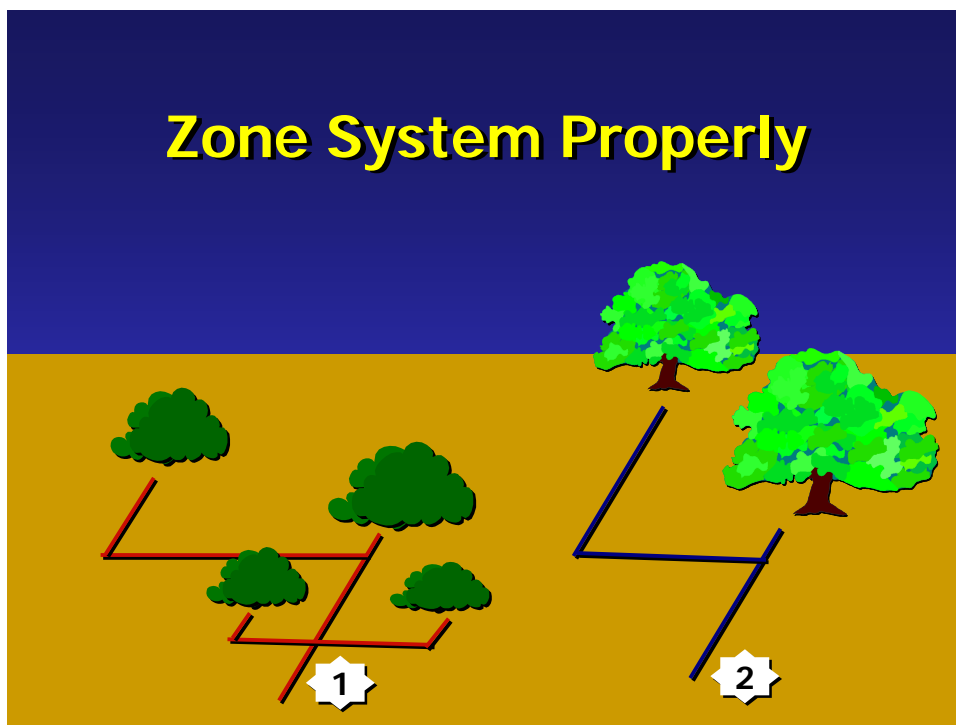


Figure 1. Irrigate trees and shrubs in different zones.

Within each zone, it is likely that each drip emitter or bubbler will water a different size plant because of variable plant growth rates. Thus, it is necessary to increase bubbler flow rate for larger plants and vice versa for smaller plants. Bubbler flow rate is adjusted by turning the screw on the adjustable bubbler. Each type of bubbler has a unique screw mechanism so the relationship between number of screw turns, flow rate and pressure is unique for each bubbler. The relationship between flow rate and normalized number of screw turns (figure 2) was measured by Yuan (2002): in order to show the difference between flow characteristics of the different bubblers, the number of 360 degree screw or cap turns was normalized to a 0-1 range.

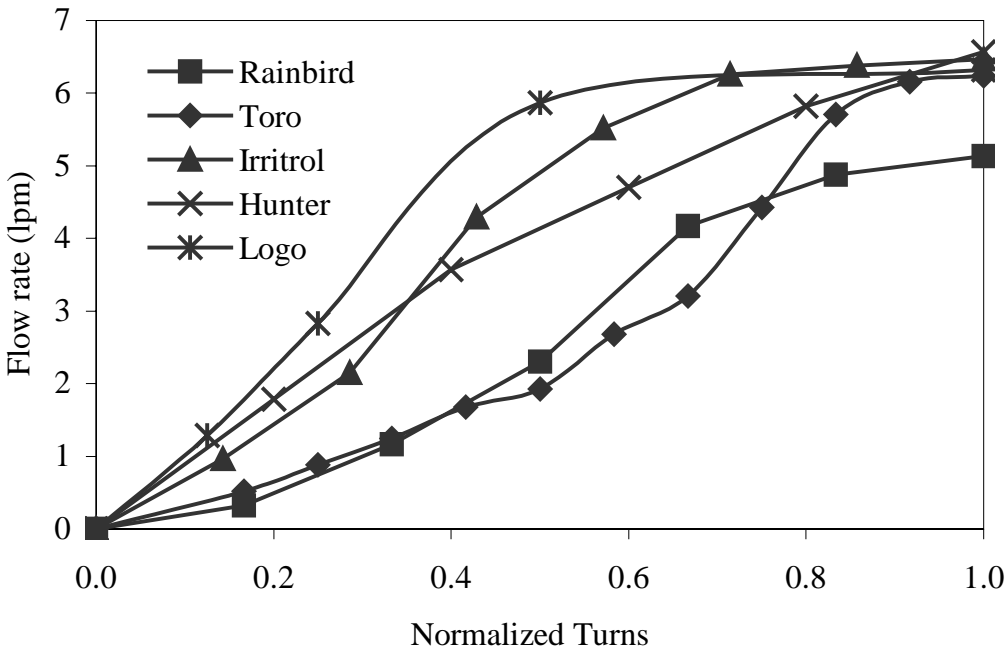


Figure 2. Flow rate vs. number of screw turns (normalized) for 5 bubblers at 140 kPa.

Design of a bubbler irrigation zone requires 9 steps:

1. Calculate each plant's daily irrigation requirement (LPD).
2. Calculate each plant's soil water holding capacity (S).
3. Find the plant with the highest daily irrigation requirement in the irrigation zone
4. Calculate the water requirements of all other plants in the zone as a percentage of the water requirement of the largest tree in the zone.
5. Calculate the maximum flow possible from the bubbler brand that is used, and assign this flow rate to the plant with the highest water requirement. Calculate the flow to all other plants as the product of the (percent of the maximum water requirement) \* (maximum bubbler flow rate).
6. Design the pipe system to connect the bubblers to the irrigation valve.
7. If basin volume is less than SWHC, then  $S = \text{basin volume}$
8. Calculate the days between irrigations as  $S / \text{LPD}$  for the largest plant.
9. Calculate the watering time as  $S / \text{LPM}$  for the largest plant (maximum flow rate).

**Example.** Design a bubbler irrigation system for the 4 maple trees in figure 3. Use Hunter bubblers. The pressure on the discharge side of the valve is 288 kPa. Design for Flagstaff in the summer. Assume that maple tree rooting depth is 1.5 m. Let  $MAD = 0.5$ . Soil is sandy loam. Depth of 2 m basins is 7 cm. Assume that there is no slope on the property.

Always design the irrigation system for the peak ET. Assume that the manager will decrease water application rates during cooler parts of the year. Assume that maximum  $ET_0$  in Flagstaff is 10 mm/day. Assume that Maple trees have a species coefficient,  $K_s$ , of 0.5, and that the density and microclimate coefficients are 1.0.



**Calculate the water requirements of all other plants in the zone as a percentage of the water requirement of the largest tree in the zone.**

Bubblers 2-4 require  $45/80 * 100 \% = 56 \%$

**Calculate the flow to all other plants as the product of the (percent of the maximum water requirement) \* (maximum bubbler flow rate).**

Maximum flow rate from Hunter bubbler is 8.67 LPM

Calculate flow rate for bubbler 2-4.

$$Q = 0.56 * 8.67 \text{ LPM} = 4.85 \text{ LPM}$$

**Design the pipe system to connect the bubblers to the irrigation valve.**

The pipe system includes 4 lengths of 5 m pipe.

The first pipe carries the entire flow =  $8.67 + 4.85 * 3 = 23.2 \text{ LPM} = 0.39 \text{ LPS}$

The second pipe carries the flow for bubblers 2-4 =  $4.85 * 3 = 14.55 \text{ LPM} = 0.24 \text{ LPS}$

The third pipe carries the flow for bubblers 3 and 4 =  $9.7 \text{ LPM} = 0.16 \text{ LPS}$

The last pipe carries  $4.85 \text{ LPM} = 0.081 \text{ LPS}$

Use one inch (25 mm) diameter pipe for the entire system. Calculate pressure loss in each pipe with the Hazen-Williams equation.

$$H_{L1} = 1.22 * 10^{10} * 5 \text{ m} \left( \frac{\left( \frac{0.39}{140} \right)^{1.852}}{25^{4.87}} \right) = 0.17 \text{ m}$$

$$H_{L2} = 1.22 * 10^{10} * 5 \text{ m} \left( \frac{\left( \frac{0.24}{140} \right)^{1.852}}{25^{4.87}} \right) = 0.07 \text{ m}$$

$$H_{L3} = 1.22 * 10^{10} * 5 \text{ m} \left( \frac{\left( \frac{0.16}{140} \right)^{1.852}}{25^{4.87}} \right) = 0.03 \text{ m}$$

$$H_{L4} = 1.22 * 10^{10} * 5 \text{ m} \left( \frac{\left( \frac{0.081}{140} \right)^{1.852}}{25^{4.87}} \right) = 0.01 \text{ m}$$

Calculate pressures in the pipeline. First calculate pressure loss in each section in kPa.

Pipe 1 → 0.17 m \* 9.86 kPa / m = 1.7 kPa pressure loss

Pipe 2 → 0.07 m \* 9.86 kPa / m = 0.7 kPa pressure loss

Pipe 3 → 0.03 m \* 9.86 kPa / m = 0.3 kPa pressure loss

Pipe 4 → 0.01 m \* 9.86 kPa / m = 0.1 kPa pressure loss

Find pressures at each bubbler

Discharge side of valve = 288 kPa

Bubbler 1 = 288 – 1.7 = 286.3 kPa

Bubbler 2 = 286.3 – 0.7 = 285.6 kPa

Bubbler 3 = 285.6 – 0.3 = 285.3 kPa

Bubbler 4 = 285.3 – 0.1 = 285.2 kPa

**Check basin volume. If basin volume is less than S, then S = basin volume**

$$\text{Basin volume} = \pi * D_b^2 / 4 * \text{depth} * 1,000 \text{ L/m}^3 = 3.14 * 2^2 * 0.07 \text{ m} * 1,000 = 879 \text{ L}$$

The basin volume is not limiting so S = 288 L

**Calculate the days between irrigations as S/LPD for the largest plant.**

$$\text{Days} = S / \text{LPD} = 288 / 80 = 3.6 \text{ days}$$

This is not a very long time between irrigations. One could **possibly** put on 10 % extra water and hope that the plant root zone would be great enough to use the water. Then, irrigation could take place every 4 days. The other option is to increase the size of the basin and increase the number of bubblers so that the soil can store more water.

## **Calculate the watering time as S / LPM for the largest plant (maximum flow rate).**

Minutes = S / LPM = 288 / 8.64 LPM = 33 minutes

Possibly, increase the time to 36 minutes in order to go 4 days between irrigations.

Because the smaller trees were irrigated at a fraction of the rate for the large tree, all trees are provided the correct amount of water and can be on the same watering schedule.

In summary, there are many sources of potential error in calculating water application rates to landscape plants and plant water requirements, and there can be a high manufacturers variability in bubbler flow rates. It is best to measure and adjust bubbler flow rates as the irrigation system is running. It is also wise to adjust the system based on observations of plant response to watering over time.

## ***References***

Yuan, Zhixu. 2002. Flow variation in irrigation system components. Ph. D. dissertation. Agricultural and Biosystems Engineering. University of Arizona.