# 15 Landscape Irrigation Systems

As with turf irrigation, the goal of landscape irrigation is aesthetic. Plants (trees, shrubs, groundcover, and flowers) can be irrigated to just survive or to thrive, to maintain plant biomass or to have vegetative growth. Research on landscape plant water requirements has been limited, and many systems are not adjusted to match seasonal changes or changes in plant canopy area. The largest water user in many cities is irrigation so improved irrigation management is critically important in water stressed regions. Although traditional landscape drip irrigation systems have proven to be unreliable, new systems are more reliable: multiport emitters mounted on PVC pipe, inline drip irrigation tubing, and bubbler irrigation systems. Another key to successful system performance is the proper design and installation of the control zone. The typical control zone has a ball valve, solenoid valve, filter, and pressure regulator installed in a valve box. This chapter focuses on the installation methods and components in landscape irrigation systems. This chapter includes equations on in-line emitter coil designs around trees and bubbler adjustment. The instructor may decide not to include this information since these are not normally part of the design process.

## Status of Landscape Irrigation Systems

The author did a survey of landscape drip irrigation systems in Phoenix, Arizona in the early 90s. The city encourages the use of low water use plants and drip irrigation as water saving techniques – Xerigation. Although drip irrigation can be efficient in agriculture when systems are carefully maintained and scheduled by skilled farmers, drip systems in urban landscapes, with minimal flow rates under the plant canopy are generally unseen and neglected. Emitters tend to plug or develop high flow rates, and maintenance is minimal and rare. Sadly, water use in poorly managed Xerigation systems is often higher than in turf irrigation systems. Nevertheless, the great majority of landscape industry professionals and homeowners thought that drip irrigation is an excellent and efficient irrigation system. The study found that the great majority of professionals, let alone homeowners, could not calculate a drip irrigation schedule.

**In-class Exercise 15.1** Could people gain a "feel" for the water requirements of plants and the length of time to water per week without actually calculating depths of water to apply?

If people cannot calculate the amount of water that plants need, then would you trust their judgment that drip irrigation is an excellent watering system?

Does it really matter if urban drip irrigation systems are efficient or uniform since plants just grow more if they get more water?

The first author and colleagues from the City of Phoenix analyzed 40 landscape drip irrigation systems, nearly all of which were professionally-maintained commercial or municipal systems. At the time, most drip systems had individual or multiport emitters plugged into polyethylene laterals with barbed fittings. If sites had components that operated correctly, then the site was given a score of 1. If the components at a site were missing or not operating correctly, then the site was given a score of zero. Number of acceptable sites was divided by total number of sites and multiplied by 10 to calculate a score between 0 and 10 (Table 15.1). Scores for each type of component are listed in Table 15.1. For example, a score of 1 meant that 4 out of 40 sites were acceptable.

One of the common problems with the systems was that landscaping tools, insects, or animals broke or chewed through the polyethylene tubing. When this happened, dirt entered the systems before or during the repair, and this led to plugging. Once emitters begin to plug, further attempts to "repair" the system often made things worse. For example, a drip system in a Phoenix park was trenched through by a fiber optic company and dirt was allowed to enter the system. In order to "clean out" the system, workers at the site



P. Waller, M. Yitayew, *Irrigation and Drainage Engineering*, DOI 10.1007/978-3-319-05699-9_15

**Table 15.1** Drip irrigation component ratings

| Parameter | Rating |
|---|---|
| Pressure regulators | 7 |
| Lateral hydraulics | 6.6 |
| Solenoid valves | 9.6 |
| Wire ties (not water proof rec. 0) | 8 |
| Flush valves (missing received 0) | 1 |
| Backflow preventor installation | 4.2 |
| Automatic controllers | 8.7 |
| Filters | 7.2 |
| Maintenance practices | 0.25 |
| Distribution uniformity | 0 |
| Efficiency | 1.2 |
| One-year old polyethylene laterals | 9 |
| Older polyethylene laterals | 2 |
| Old PVC laterals | 9.5 |

removed the pressure regulators and permanently damaged the emitters by running them at 80 PSI (560 kPa) city pressure and blowing diaphragms out of emitters.

One of the problems with using compression or barbed fittings is that the connections are not as secure as PVC with glued or screwed fittings. When emitters pop out of distribution tubing or tubing is damaged, a stream of water sprays onto the landscape like a fountain.

Another common problem was that emitters were left running after plants died. It was quite common to see landscape irrigation systems watering large areas with no plants.

Approximately 2/3 of landscape drip irrigation systems had acceptable hydraulics (Table 15.1). Drip tubes can extend for hundreds of feet in landscapes without having unacceptable pressure losses. Generally, the components in the valve boxes (solenoids, filters, and pressure regulators) and controllers were in acceptable working order (Table 15.1). This is because these components must be fixed when the system breaks down or the system does not work at all.

Uniformity was measured. In landscape irrigation, the measurement of uniformity is complicated by the fact that the plants are different sizes; however, landscape irrigation uniformity was evaluated by measuring the volume applied to each plant and dividing by the canopy area. Distribution uniformity (DU) is the lowest quarter of depths divided by the average depth. Agricultural drip system DU is expected to be in the range of 90 %: all drippers flow at approximately the same rate. Distribution uniformity (DU) of landscapes in the study averaged less than 20 % (Fig. 15.1). The Irrigation Association recommends uniformities of 80 % for drip/micro irrigation. Only one site had a DU greater than 70 %. Not coincidentally, this was the only site that was managed by someone who could actually calculate irrigation requirements and conscientiously adjusted the number of drip emitters and irrigation timing to match irrigation requirements. The actual uniformities were even worse than reported because fountain emitters and completely plugged emitters were not included in the analysis. In addition, neither were areas with a multitude of emitters and no plants.

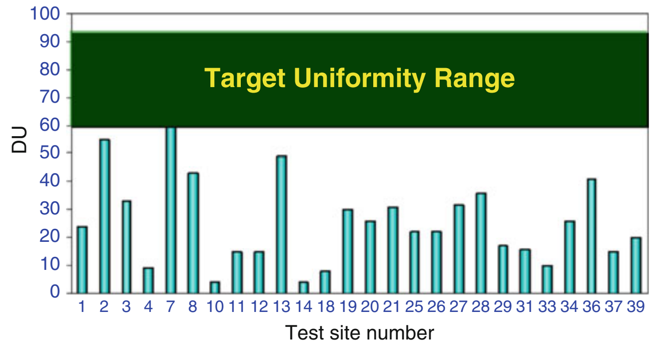



**Fig. 15.1** Distribution uniformity at drip irrigation sites in Phoenix (Credit Aung Hla, University of Arizona)

Statistical uniformity (SU) is another method of calculating irrigation uniformity.

$$SU = 1 - \frac{standard\ \ deviation}{mean} \quad (15.1)$$

Average statistical uniformity at the sites was negative 40 %. This means that the standard deviation of application depths was 40 % greater than the mean of the application depths. The conclusion of the study was that barbed emitters are unreliable and the PVC mounted multiport emitters, bubbler irrigation, and inline tubing are preferable alternatives.

Irrigation efficiency is the recommended rate of water use divided by the applied water. The efficiencies at the Phoenix drip study sites were measured by evaluating the controller irrigation schedules. The efficiencies (Fig. 15.2) were extremely variable, which is an indication that managers do not know how to adjust controllers. There is really no such thing as greater than 100 % efficiency as shown in Fig. 15.2; however, in this case, greater than 100 % efficiency means that less water was applied than was required.

## Landscape Irrigation Control Zones

A control zone is placed at the entrance to every drip irrigation zone. It should include a manual ball valve, a solenoid valve, a filter, and a pressure regulator (Fig. 15.3). The solenoid valve, filter, and pressure regulator assembly are typically placed below the soil surface in a valve box. One to several valves (control zones) can be placed in a valve box. Fittings should be placed far enough apart so that unions can be unscrewed and the individual control zones removed for repair or replacement. Valves boxes should be installed in

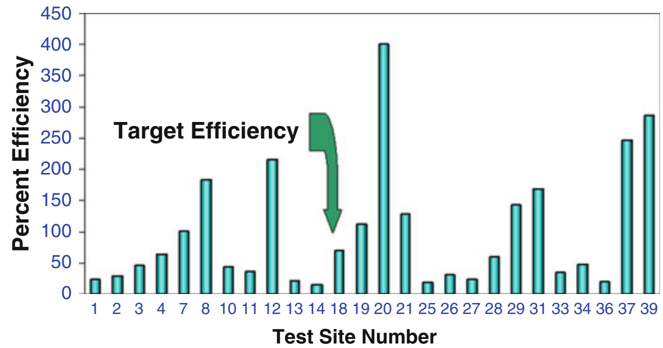



**Fig. 15.2** Efficiencies of drip irrigation sites in Phoenix (Credit Aung Hla, University of Arizona)

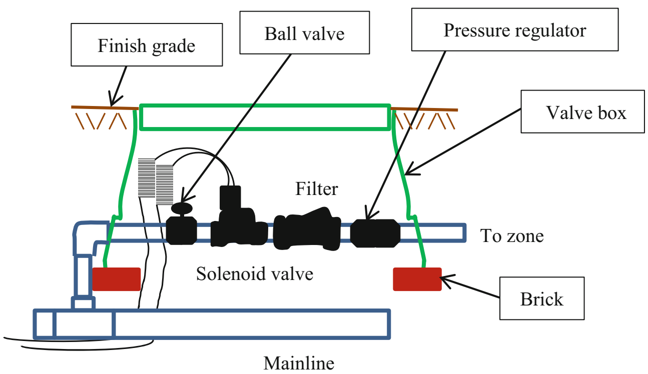



**Fig. 15.3** Control zone components in valve box

such a way that they do not fill with mud. The top of the valve box should be at or above grade (Fig. 15.3). It should not be placed in a depression such that mud and water regularly flow into the valve box. The lower part of the box should be wrapped with geotextile cloth in order seal the valve box from insects and soil. The chemical WD-40 can be sprayed into the valve box in order to discourage insects. The mainline runs under the valve box and a riser connects to the control zone (Fig. 15.3). Solenoid valve wire is special coiled wire that allows the solenoid to be removed but also does not become a mess in the box. Electrical connectors that connect the controller wire to the solenoid valve are waterproof silicon-filled connectors. The bottom of the box should be filled with 75 mm depth of gravel in order to keep the valve box clean. The valve box should be leveled on bricks before gravel and backfill are added (Fig. 15.3). On many commercial projects, a mainline runs around the property, and valves are grouped along the mainline in subsurface valve boxes.

Irrigation controllers are powered by standard 110 V AC current. A hole can be drilled in the wall of the building in order to bring wires by conduit from an electrical socket or other location to the controller. The controller outputs 24 V power to the solenoid valves. One common wire (usually white) from the controller is connected to all solenoid valves and the controller. One 24 V "hot" wire is connected to each valve. Protection of electrical wiring is important. Metal conduit should be used to protect 110 V wire from the building to the controller. The 24 V valve wires should also be encased above ground. However, once the wires (i.e., #14 AWG) are in the ground they can buried without a conduit. The wires should be placed below the water pipes in the trench in order to protect them; thus, they are laid in the trench before the water pipes.

Special solenoid valves are required for low flow drip irrigation zones. The higher flow rate valves will not shut off properly in a low flow zone. If a low flow valve is used in a high flow rate sprinkler zone, then pressure loss is excessive.

Prior to the control zone, a backflow prevention device should isolate the irrigation system from the municipal water supply. If this is not done, then harmful chemicals could enter the potable water supply and cause sickness. The type of backflow prevention device depends on many factors such as whether or not chemigation is used and the topography of the property. Local municipal regulations should be consulted in order to select the correct backflow prevention device.

## Drip System Design

In theory, there should be enough emitters to cover the root zone of the tree (beyond the canopy), however, the high cost of emitters can make this financially impractical. In the study of drip irrigation systems in Phoenix, Arizona, the average distance of emitters from trees was 1.3 feet and the average tree canopy width was 17 feet.

Multioutlet emitters threaded onto PVC risers and placed in valve cans (Fig. 15.4) are much easier to identify (Fig. 15.5) and maintain. Many of the problems associated with landscape drip irrigation are eliminated. The emitters are easily found and accessed in the cans and there are no unreliable polyethylene connections or barbed fittings. Distribution tubing goes out under the can to the watering points.

Another reliable landscape drip alternative is inline drip irrigation with the emitters manufactured into the tubing. There are several reasons for the surge in popularity of inline drip irrigation: (1) inline emitters have a lower cost per wetted area than single or multiport emitters, (2) it is easy to replace the entire inline lateral when the emitters or tubing wear out, (3) inline drip irrigation tubing lasts longer than point source drip emitters, (4) even if one or two emitters go bad, there are many other emitters, and (5) many inline drip emitters are self-flushing and pressure compensating.

Inline drip tubing is manufactured from polyethylene, and it can be exposed to direct sunlight. However, on commercial sites, it may be preferable to bury the tubing under mulch in order to prevent vandalism. The need to bury the tubing is most important in areas with high traffic where people might abuse the tubing. If the tubing is buried directly in the soil, then there is a possibility that some plant roots will grow into the emitters. Some emitters are impregnated with an herbicide or seal when not in use in order to prevent root intrusion.

**Fig. 15.4** Multioutlet emitter in valve can

An exposed inline emitter and tubing is shown in Fig. 15.6. One inlet to the emitter provides backpressure behind a pressure compensating diaphragm, and the other is the entrance to the turbulent flow path. As pressure increases, the diaphragm closes down and restricts flow.

One of the advantages of inline tubing is that it creates a line source of water, and plants will grow roots along the tube. The increased root development is better for the plant than the restricted root development around a single point source emitter. In order to create a line source, the distances between emitters along inline tubing should be less than the wetted diameter (3/4 of the wetted diameter) as shown in Fig. 15.7.

Emitter wetted diameter is a function of emitter flow rate and soil infiltration rate. Approximate wetted diameters are shown in Table 15.2.

The salts in irrigation water remain in the soil as the water evaporates from the soil surface. In drip irrigated soils, the salts tend to be pushed to the edges of the wetted area, and rings of salt can be seen around emitters. If emitters spacing

**Fig. 15.5** Multioutlet emitter valve cans in landscape

**Fig. 15.6** Inline drip tubing

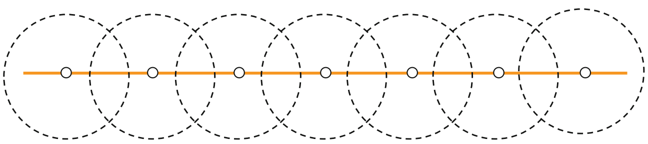


**Fig. 15.7** Wetted diameter and spacing along inline drip irrigation tubing

**Table 15.2** Wetted diameters (m) for drip irrigation emitters (After Benami and Ofen 1984)

| Soil type | Emitter flow rate (Lph) | | |
|---|---|---|---|
| | 2 | 4 | 8 |
| | Wetted diameter (m) | | |
| Light (sand) | 0.3 | 0.6 | 1.0 |
| Medium (loam) | 0.7 | 1.0 | 1.3 |
| Heavy (clay) | 1.0 | 1.3 | 1.7 |

is slightly wider than the wetted diameter, then salts will concentrate between emitters as they are pushed to the edges of the wetted diameter. Thus, inline tubing should be laid next to the plant as shown in in order to push the salts away from the root zone, and emitter spacing should be close enough to prevent salt accumulation between emitters. Alternating tubing from one side of the plant row to the other helps keep tubing next to plants.

**In-class Exercise 15.2** What is the maximum distance between 4 LPH emitters in order to create a line source wetting pattern in a sandy soil? Would you select 30, 45, or 60 cm spacing?

One option for laying tubing around a tree that minimizes the need for fittings is to coil the tubing around the tree (Fig. 15.8). The distance between coils should be slightly less than the wetted width of the line source. The faded area

**Fig. 15.8** Coil of inline drip tubing around tree

in Fig. 15.8 is the wetted area and the darker line is the drip tubing. The outer circle is the canopy diameter.

An equation can be developed that solves for the wetted area as a function of the length of tubing and the number of coil turns. If tubing begins half of the wetted diameter away from the tree, then the distance of the inner end of the tubing from the trunk center is the trunk radius + half of the wetted diameter. The coil should increase in radius by the wetted diameter for every 360° coil.

An following equation calculates the distance of the end of the coil from the center of the canopy:

$$r_{end} = r_t + \frac{B}{2} + (B)C \tag{15.2}$$

where

$r_t$ = trunk radius, m
B = distance between successive coils of tubing, m
C = number of complete coil turns (360°), dimensionless
$r_{end}$ = distance of the end of the tube from trunk center, m.

The change in tubing length, dL, for any change in number of coil turns, C, is

$$dL = 2\pi \; rdC \tag{15.3}$$

Rearrange and solve for r as a function of L and C.

$$r = \left(\frac{dL}{2\pi dC}\right) \tag{15.4}$$

Substitute Eq. 15.4 into Eq. 15.2.

$$\begin{aligned} \frac{dL}{2\pi dC} &= r_t + \frac{B}{2} + (B)C \\ dL &= 2\pi B\left(\frac{r_t}{B} + \frac{1}{2} + C\right)dC \end{aligned} \tag{15.5}$$

Integrate Eq. 15.5.

$$\int_0^L dL = 2\pi B \int_0^C \left(\frac{r_t}{B} + \frac{1}{2} + C\right) dC$$
$$L = 2\pi B\left(\left(\frac{r_t}{B} + \frac{1}{2}\right)C + \left(\frac{C^2}{2}\right)\right) \qquad (15.6)$$
$$L = \pi B\left(\left(\frac{2r_t}{B} + 1\right)C + C^2\right)$$

The average wetted area under the canopy is calculated based on the end of the tube radius from the trunk, $r_{end}$, because the wetted area is r + WD/2 at the end of the coil, but it is r − WD/2 at the outer edge of the previous coil. Thus, the differences in area cancel. Rearrange Eq. 15.2 in order to solve for C as a function of $r_{end}$.

$$C = \frac{r_{end} - r_t - \frac{B}{2}}{B} \qquad (15.7)$$

The wetted area as a function of the distance of the end of the drip tube from the trunk center is

$$A_{wetted} = \pi r_{end}^2 \qquad (15.8)$$

The ratio of the wetted area over the entire canopy area is

$$\frac{A_{wetted}}{A_{canopy}} = \frac{r_{end}{}^2}{r_{canopy}{}^2} \qquad (15.9)$$

Based on Eq. 15.9, if the ratio of $r_{end}$ to the canopy radius is 1/2, then the ratio of the wetted area to the canopy area is ¼.

If the tubing length, L, is known, then a quadratic equation can be used to solve Eq. 15.6 for C, the number of turns of the coil.

$$-L + \pi B\left(\left(\frac{2r_t}{B} + 1\right)C + C^2\right) = 0$$

where

$$a = \pi B, \quad b = \pi B\left(\frac{2r_t}{B} + 1\right) = \pi(2r_t + B), \quad c = -L$$

$$C = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
$$= \frac{-\pi(2r_t + B) \pm \sqrt{(\pi(2r_t + B))^2 + 4L\pi B}}{2\pi B} \qquad (15.10)$$

**Example 15.1** Find the length of coiled tubing required to wet ¼ of the canopy area of an 8 m diameter orange tree. Soil is sandy, and emitter flow rates are 4 LPH. The tree trunk is 0.3 m diameter. Determine the cost of tubing per tree if the inline tubing costs $0.76/m.

In sandy soil with approximately 4 LPH flow rate, the wetted width from the irrigation tubing is 0.6 m (Table 15.2). Thus, the coil can be placed around the tree with coils approximately 0.6 m apart.

Based on Eq. 15.9, if the ratio of wetted area to canopy area is ¼, then the ratio of the coil radius to canopy radius is ½; thus, if the canopy diameter is 8 m, then the distance from the tree center to the end of the coil, $r_{end}$, is 2 m. Number of coil turns is calculated with Eq. 15.7.

$$C = \frac{r_{end} - r_t - \frac{B}{2}}{B} = \frac{2 - 0.15 - \frac{0.6}{2}}{0.6} = 2.58 \ \ turns$$

Find the required length of tubing

$$L = \pi B\left(\left(\frac{2r_t}{B} + 1\right)C + C^2\right)$$
$$= \pi * 0.6\left(\left(\frac{2*0.15}{0.6} + 1\right)*2.58 + 2.58^2\right) = 20 \ \ m$$

The cost of tubing is 20 m * $0.76/m = $15.20.

**Example 15.2** For the parameters in Example 15.1, find the fraction of canopy area wetted with a 10 m length of tubing.

Use Eq. 15.10 to find the number of turns in the coil.

$$C = \frac{-\pi(2r_t + B) \pm \sqrt{(\pi(2r_t + B))^2 + 4L\pi B}}{2\pi B}$$
$$= \frac{-\pi(2*0.15 + 0.6) \pm \sqrt{(\pi(2*0.15 + 0.6))^2 + 4*10*\pi*0.6}}{2*\pi*0.6}$$
$$= \frac{-\pi(0.9) \pm \sqrt{(\pi*0.9)^2 + 24*\pi}}{1.2*\pi} = 1.67 \ \ turns$$

The end radius with the 10 m tube can be calculated with Eq. 15.2.

$$r_{end} = r_t + \frac{B}{2} + BC = 0.15 + \frac{0.6}{2} + (0.6)(1.67) = 1.45 \ \ m$$

For the 8 m diameter tree, this would result in a percent wetted area of

$$1.45^2/4^2(100\%) = 1.32/16(100\%) = 13\%.$$

One technique used to encourage root growth is to move drip emitters away from the trunk toward the edge of the canopy as the tree grows. This encourages the roots to continue to move outward toward the edge of the canopy. Encouraging the roots to grow outward provides a better anchor for the tree and prevents toppling in high winds. One of the advantages of a coil is that it can easily be extended outward as the plant grows.

Inline tubing is used in beds with ground cover or flower. Parallel rows of tubing are connected to polyethylene or PVC headers at both ends of the planter. For short tubing lengths, inline emitter tubing is manufactured in 1/4″ (7 mm) diameter.

## Bubbler/Water Harvesting Irrigation Systems

An alternative to drip irrigation that preceded drip irrigation is bubbler irrigation (Fig. 15.9). Bubblers operate at a much higher flow rate (0.5-, 1-, or 2-GPM; 2-, 4-, or 8-LPM) than drip irrigation systems; thus, they have larger orifices and don't require filtration. The disadvantage is that more zones are needed. They are installed on black flexible PVC pipe with glued and screwed connections. Thus, the bubblers and pipe systems are more durable than typical drip systems and are not as readily broken by landscape tools, degraded in heat, or consumed by animals or insects. However, bubblers are more difficult to install because trenched PVC pipe must be routed to each bubbler.

**Fig. 15.9** Bubbler at base of shrub

Bubblers are mini flood irrigation systems. As such, they can work in concert with a water harvesting system if they are installed in a contoured basin landscape profile (Fig. 15.10). The contours direct rainwater to the plants. Contoured basins are stable and do not break down over time. The high points between plants should be approximately 50–100 mm (2–4 inches) higher than basin low points.

Bubblers are not suitable for densely planted landscapes because the water output per unit area is high. They are more appropriate for widely spaced shrubs and trees that can be surrounded by a basin; in general, it is difficult to supply more than one plant with an individual bubbler. If canopy area and basin diameter are large, then two bubblers may be required to cover the entire basin. Basins can be a several centimeters below grade, and mounds several centimeters above grade in order to avoid adding or removing soil from the site. Plants that are susceptible to trunk rot, such as pine trees, should be placed in donut shaped basins (Fig. 15.11) so that the trunk will not remain wet for an extended period.

Flexible PVC can be used to connect the bubbler to the PVC lateral pipe (Fig. 15.10). A gray ½″ electrical male adapter connects the bubbler to the flexible PVC. Orienting the lateral Tee sideways (Fig. 15.12) can minimize the amount of tubing out of the ground and allows the bubbler to be run in a shallow trench to the watering location. In this way, one lateral can be trenched in the center of a landscaped area and flexible black PVC pipe can be used to connect the bubblers to the main lateral without excessive trenching.

There are two primary types of bubblers: pressure compensating and adjustable flow. Pressure compensating bubblers have a relatively constant flow rate over a range of pressures and are generally available in 2-, 4-, 6-, and 8-LPM flow rates. One problem with some pressure compensating bubblers is that the little O-shaped rubber ring that maintains constant flow sometimes becomes dislodged and cuts off nearly all flow. Adjustable flow bubblers can be adjusted for flows between 0- and 8-LPM.

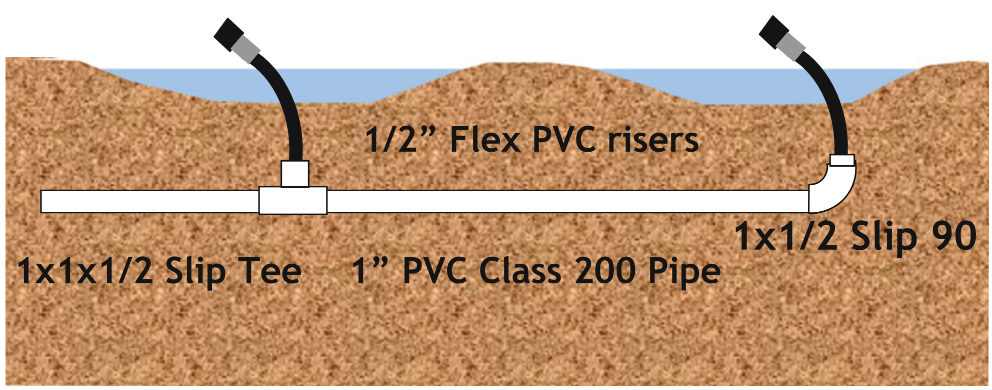
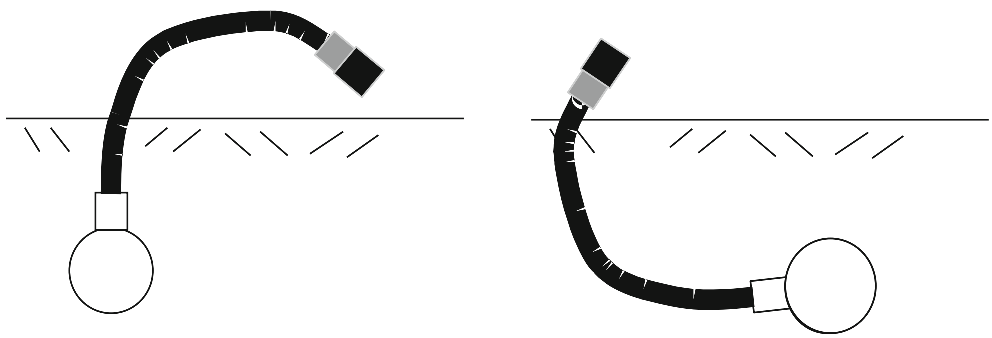



**Fig. 15.10** Contoured basin design for bubbler/water harvesting systems

**Fig. 15.11** Bubbler irrigation of pine trees

**Fig. 15.12** Sideways Tee orientation can reduce unsightly pipe above the ground



Bubbler flow rate vs. pressure can be modeled with the emitter exponent equation.

$$q = kH^x \tag{15.11}$$

where

q = bubbler flow rate, lpm
k = coefficient, dimensionless
H = pressure, kPa
x = exponent, dimensionless.

Unlike sprinklers, which have an exponent of 0.5 because flow passes through a round orifice, adjustable bubblers have a more complex flow path. This is complicated by the fact that the flow path geometry changes as the screw cap is adjusted. The author and Zhixu Yuan measured flow rates at different screw and cap positions and pressures (140 and 210 kPa) and developed equations for x (Fig. 15.13) and k (Fig. 15.14) as a function of number of turns for 5 different bubblers. The k and x values were calculated for each screw turn position as shown in Eqs. 15.12 and 15.13.

$$x = \frac{\log(Q_{140}) - \log(Q_{210})}{\log(140) - \log(210)} \tag{15.12}$$

where

$Q_{140}$ = flow rate at 140 kPa, LPM
$Q_{210}$ = flow rate at 210 kPa, LPM

$$k = \frac{Q_{140}}{140^x} \tag{15.13}$$

With some bubblers, flow rate is adjusted by turning a screw. Others are adjusted by turning a cap. Each brand of bubbler has a unique screw mechanism so the relationship between number of screw turns, flow rate and pressure is unique for each bubbler. Figure 15.13 shows the x value as a function of the number of 360° turns. This graph also indicates the range of turns for each bubbler. The equations next to each curve give the relationship between x and number of 360° turns, T.

The k value in Fig. 15.14 is basically a unit conversion constant. The values in Fig. 15.14 refer to pressure in kPa and flow in LPM. If flow was in GPM with pressure in kPa, then the k values in Fig. 15.14 would be divided by 3.785.

**In-class Exercise 15.3** What is the exponent x for pressure compensating bubblers if flow rate does not change with pressure?

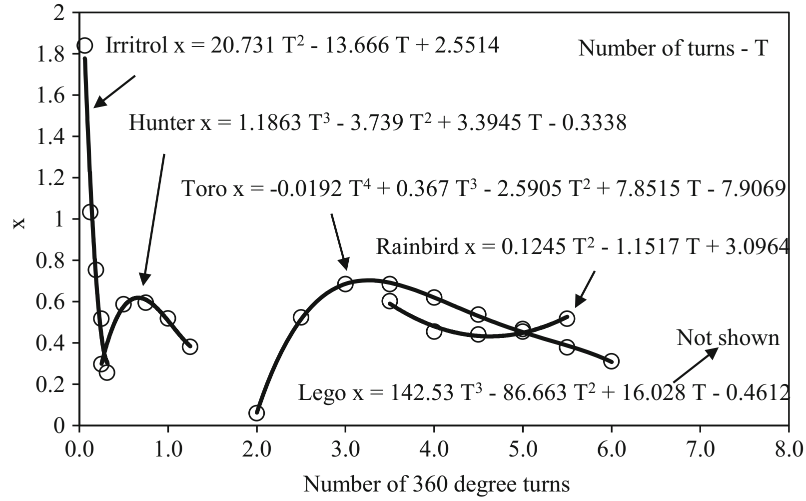



**Fig. 15.13** Bubbler flow equation exponent x versus number of turns for five bubblers

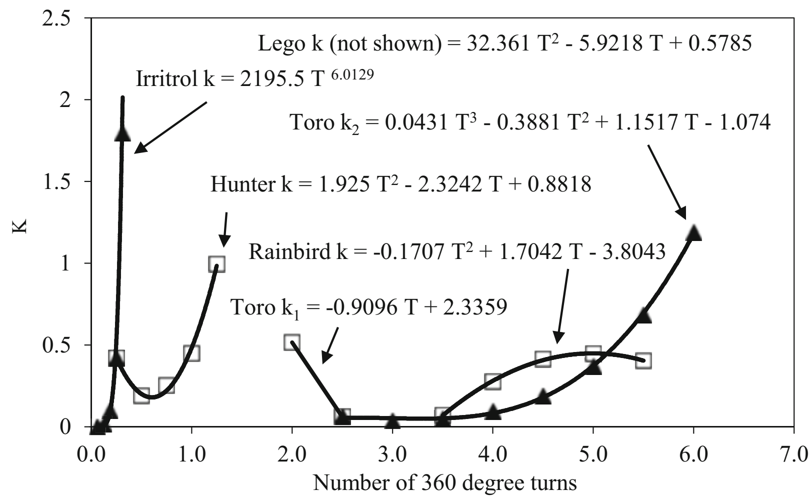



**Fig. 15.14** Coefficient k versus number of turns for flow in LPM and pressure in kPa

## Maintenance and Economics

Maintenance of landscape drip systems is rare because landscape companies are generally contracted to keep the site clean and pruned, most homeowners have other priorities, and drip components can be hidden by soil or plants. One study in Tucson, Arizona found that water usage decreases dramatically when drip systems are completely abandoned and people start watering with a hose. This is not at all surprising because people are actually observing the amount of water applied and the plant response to water application when they water with a hose. With automatic systems, the water application is generally unobserved.

Possibly, maintenance criteria used in large-scale irrigation projects can be used to evaluate maintenance of landscape irrigation systems. Gold-plated maintenance is maintenance to a level that virtually stops all system deterioration. Pragmatic maintenance attempts to keep a system in "good but not perfect working order." Minimal maintenance repairs those things that are absolutely necessary for major parts of the system to convey water, but is not concerned with levels of reliability, with some areas going out of service, or with diminished conveyance capacity. The great majority of landscape irrigation systems are maintained at the minimal maintenance level; for example, valves and automatic controllers are repaired because the system does not work at all without these components, but drip emitters are rarely adjusted or repaired.

If a drip irrigation system that waters 10 trees (4 emitters per tree) and 30 shrubs (1 emitter per shrub) is maintained once per year, then the following time investment might be necessary.

Measure distribution uniformity in the zones (4 minutes/emitter) (2 zones) (20 emitters/zone).

Calculate required flow rate per plant (3 minutes per plant) (40 plants).

Change the number of emitters per plant if necessary (5 minutes per plant) ( 40 plants).

Replace defective emitters (5 minutes per emitter) (1/5 emitters per year) (70 emitters).

Adjust emitter locations by moving distribution tubing (2 minutes per emitter) (½ emitters) (70).

The total time investment is 11 hours. If $100 replacement parts were used per visit and the cost of the worker is $40/hr, then the total cost would be $540.

## Economics

The economic benefit of landscape irrigation systems can be evaluated based on the value of the landscape. One way to assign a value to residential landscaping is to determine the relationship between the selling price of the home and landscaping. Home values increase between 10 % and 17 % if landscaping around the home is rated as good or excellent vs. poor or average. Many homes in irrigated regions have values in the range between $200,000 to $700,000. Thus, the value of landscaping ranges from $20,000 to $100,000.

**Example 15.3** Determine whether installing an irrigation system with landscaping is an economically wise choice. Assume a required rate of return of 8 % and a project life of eight years (owner will sell house in 8 years when the landscape is mature).

*Assumptions*

- Water costs for irrigation are $500/yr.
- Capital cost of installation of the irrigation system and landscaping is $5,000
- Home selling price in 8 years is expected to be $400,000.
- Irrigation system maintenance costs are $500/year
- Plant replacement costs are $200/year
- Ignore psychological benefit of looking at and interacting with landscaping, and cooling.

*Costs*

Annual costs are sum of water, maintenance, and plants: $500 + $500 + $200 = $1,200.

The present value of $1,200 payments for eight years at an 8 % rate of return is $6,900.

Total present value of costs is $5,000 + $6,900 = $11,900.

*Benefits*

The value of landscaping in eight years will be $400,000 (0.17) = $68,000.

Present value of benefits is $147,000 $(1 + 0.08)^{-8}$ = $37,000.

The present value of benefits is 3 times greater than the present value of costs.

## Questions

1. Discuss the questions presented in Exercise 15.1. How would the scientific method change the results and people's perceptions? (Write at least 1 page, double-spaced). Answers will vary.
2. Describe the components in a landscape irrigation control zone and the function of each part.
3. Describe how a controller is wired and how it controls the valves.
4. Compare the advantages and disadvantages of barbed fitting emitters, line source drip irrigation and bubbler irrigation.
5. Describe how a pressure compensating in-line emitter works.
6. Answer in-class Exercise 15.2. Using Table 15.2, determine the maximum distance between 4 LPH emitters in order to create a line source wetting pattern in a sandy soil? Would you select 30, 45, or 60 cm spacing?
7. Draw out a yard that you know about or can imagine and lay out the location of sprinklers and drip emitters. You can do this on a piece of graph paper where 1 inch = 10 ft or some other appropriate scale. You could also draw it out in a computer program. Locate positions of valves and pipes as well as define zones. For bubblers, let flow rate be 2 GPM, and for emitters let flow rate be 2 GPH. Use PVC or polyethylene tubing where appropriate. Make sure to group similar emitters in zones. Select pipe and calculate pipe friction losses.
8. Evaluate the economic costs and benefits of the following system. Assume 8 % ROR and 8 year project life.
   - Water costs for irrigation are $500/yr
   - Capital cost for installation is $1,500
   - Home selling price is $200,000 and landscaping adds 17 % to the value of home. Home will be sold in 8 years and home price is expected to decrease in value by 10 % over the 8 year period.
   - Irrigation system maintenance are $250/yr
   - Plant replacement costs are $100/yr
9. Which types of irrigation devices would be appropriate for four 5 m diameter, widely spaced, trees?
10. Which types of irrigation devices would be appropriate for 10 x 50 ft planter with ground cover?
11. If you had an oleander hedge that extended for 200 ft, which type of irrigation system would be most appropriate and why?

12. If you had six 1.2 m diameter shrubs that are spaced at 3 m interval, which type of irrigation system would be most appropriate and why?
13. Calculate the flow rate of the Toro Bubbler with three turns at 140 and 210 kPa.
14. Find the length of coiled tubing required to wet ½ of the canopy area of a 10 m diameter orange tree. Soil is clay, and emitter flow rates are 3 LPH. The tree trunk is 0.3 m diameter. Determine the cost of tubing per tree if the inline tubing costs $0.76/m.
15. For the parameters in question 14, find the fraction of canopy area wetted with a 12 m length of tubing.

## Reference

Benami A, Ofen A (1984) Irrigation engineering. Irrigation Engineering Scientific Publications, Israel Institute of Technology, Technion City, Israel