Approximately three-fourths of the earth’s land is arid or semiarid. Arid lands receive less than ten inches of precipitation per year and semiarid lands receive less than 20 inches per year. However, any given year may result in the receipt of considerably more or less precipitation than the stated averages. Since the need for water is absolute, water is probably the most critical factor in the survival and distribution of plants across the nation and the world. Irrigation is essential for all landscape plants which do not receive reliable or sufficient rainfall. Agriculture is the largest single consumer of water in the United States, as it uses 100 billion gallons of water per day solely for irrigation.

Water is a limited resource. With ever increasing demand and inconsistent supplies, interim or even long-term water shortages can occur, especially in drier areas. Responsible water usage in nursery production and landscape and turf management, as well as water-conscious plant selection in landscape designs will serve to enhance nursery production and sustain the landscape. Nursery and landscape professionals need to be ever diligent about water usage and keep abreast of water usage and runoff regulations. Nursery and landscape professionals need to become proactive in the community on water regulation issues. They should request membership on city, county or state water boards or agencies.

In areas where water supplies are inconsistent, plant selection is a primary tool to manage water consumption. A list of plants that are known to use or need less water to thrive should be utilized. Refer to the chapter on Trees, Shrubs and Vines for information on drought tolerant plants. Adequate mulching will also aid in water retention. The utilization of these two tools will help eliminate the need for high levels of supplementary irrigation in many situations.

Lack of sufficient water for plant growth is devastating, however, over-watering is just as detrimental and perhaps even more devastating. Injury from water deficiency is usually readily apparent and often easily corrected, however, injury from over watering is less easily detected and, therefore, may result in severe injury or death of the root system, and subsequently the plant, before corrective action, if any, can be taken.

Irrigation Basics
The benefits and the necessity for irrigation in the green industry are widely recognized. Unfortunately, however, understanding of water and plant vigor relationships is often limited to: “None is bad, some is good and a lot is better”. Figure 1 verifies the “None is bad” part, but it also shows that once the optimum moisture level is reached in a given system, the “Lots is better” philosophy is counterproductive. Not only is it wasting water, but this type of management costs money to procure or pump water that is decreasing plant growth, yield and quality.

Water volume or quantity actually required for irrigation depends on many different factors. The most accurate means of determining that a plant’s water requirements are not only being met, but are not exceeded, is to monitor actual soil moisture content. This can range from manually reading a soil moisture sensing device and timing irrigation accordingly, to automated systems that constantly monitor soil moisture at multiple sites and provide water on demand as predetermined lower and upper soil moisture thresholds are met. In either case irrigation is initiated before plant moisture stress begins to occur. In the latter case, being a closed loop system, irrigation is inhibited once the soil’s capacity to hold water is met either by irrigation or natural precipitation.

Although soil moisture monitoring may be the most accurate means of meeting a plant’s water requirements, the technology investment and the intense design and management practices inherent in this method may not be best for every situation. The most popular and relatively simple method of estimating how much water is needed is the use of evapotranspiration (ET) data. This method shall be used here for explaining and determining plant water requirements. Evapotranspiration is defined as the sum of water lost from the soil surface, which is evaporation, plus water lost by plants through transpiration. It is usually expressed in Inches per Day. Evapotranspiration values for a particular site can be estimated in numerous ways. The most common methods involve estimating or measuring evaporation at a specific location, and then inserting this data into
various formulas that adjust for factors that affect ET such as plant species, growth stage, plant density, and microclimate. These formulas can be relatively simple or quite complex depending on the degree of accuracy required.

The most common method of estimating ET is the measurement of open pan evaporation. Figure 2 shows a USDA Class A evaporation pan. The dimensions and construction of this pan are very specific so that sampling variation in data collected from different pans at different sites is minimal. In practice, almost any round, shallow vessel will work as long as the sides are straight rather than sloped. The pan should be placed where it will be exposed to natural precipitation and measurements should be taken at approximately the same time each day. Animals should be prevented from using the pan by fencing the area or by securing a wire screening over the top.

Another popular source for estimated ET data is the use of weather stations, satellite telemetry and computer modeling. Figure 3 shows a daily estimated ET map generated from such a system.

Using ET data, the following irrigation basics can be calculated:

1. **Irrigation Requirement (IR)** – How much water, in Inches per Day, must be applied?

2. **Required Water Source Capacity** – How much water, in Gallons per Minute, must a water source be capable of supplying?

3. **Irrigation Run Time** – How much Time in Minutes must the irrigation system run to satisfy the Irrigation Requirement?

**Irrigation Requirement** – Table 1 illustrates the most basic expressions of an Irrigation Requirement. **Crop Coefficient (KC)** is a factor used to account for the different rates of transpiration for different plant species. Values for crop coefficients are sometimes available through local sources such as a local County Cooperative Extension Service. If crop coefficients are not available, assume a high consumption rate and use KC = 1. **Application Efficiency (AE)** is a catch-all expression for efficiency and uniformity. Efficiency refers to how much of the applied water actually ends up in the soil at the target area. Uniformity refers to how uniformly the applied water is distributed in the target area. Application Efficiency can vary widely depending on the irrigation method employed and on the system design. A well designed drip irrigation system can achieve an AE in the 90% range, while a poorly designed overhead irrigation system will achieve an AE in the 30% range. Table 1 also illustrates the formula and calculations for the Irrigation Requirement of 0.21 inches per day assuming an ET of 0.20 Inches per Day, a KC of 0.80, and an AE of 75%. 

![Figure 1. Uniformity and optimum moisture levels are essential for optimum yields, wherein too little or too much water significantly reduces crop yield.](image)
Figure 2. USDA Class A Evaporation Pan used to determine ambient evaporation rates.

Figure 3. Daily estimated Evapotranspiration (ET) map generated from weather stations, satellite telemetry or computer modeling.
Table 1. Formula and calculations for determination of a specific **Irrigation Requirement**, measured in Inches per Day.

### Irrigation Requirement

<table>
<thead>
<tr>
<th>Formula</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ IR = ET \times KC ]</td>
<td>[ IR = 0.20 \times \frac{0.80}{0.75} = 0.21 \text{ Inches per Day} ]</td>
</tr>
<tr>
<td>IR = Irrigation Requirement in Inches per Day</td>
<td>IR = 0.21 Inches of Irrigation required per Day</td>
</tr>
<tr>
<td>ET = Evapotranspiration in Inches per Day</td>
<td>ET = 0.20 Inches per Day</td>
</tr>
<tr>
<td>KC = Crop Coefficient</td>
<td>KC = 0.80</td>
</tr>
<tr>
<td>AE = Application Efficiency</td>
<td>AE = 75%</td>
</tr>
</tbody>
</table>

Having calculated the Irrigation Requirement, this requirement can now be defined in Gallons per Minute. A water source must supply this quantity in order to meet the existing IR. Table 2 illustrates that as the **Irrigated Area (IA)** increases, the **Required Water Source Capacity**, in Gallons per Minute (GPM), must increase. Conversely, as the Hours per Day available for irrigation increase, the required Water Source Capacity decreases in Gallons per Minute. Table 2 also illustrates the formula and calculations for a Required Water Source Capacity of 54.5 GPM assuming an IR of 0.21 Inches per Day, an Irrigated Area (IA) of 200,000 ft$^2$ (approximately 4.6 acres), and a Time of eight Hours per Day available for irrigation.

After determination of the quantity of water to apply (IR) has been calculated, and how many Gallons per Minute the Water Source must supply to meet that requirement, it is necessary to calculate the Time in Minutes the irrigation system must operate to meet the IR. This procedure is illustrated in Table 3 which uses many of the same variables used in previous formulas. The exception is **Precipitation Rate (PR)**. Precipitation Rate for a given irrigation system is a function of the flow rate through each sprinkler or dripper outlet, and the spacing between sprinklers or drippers. Fixed spray sprinklers in the confines of a green house or garden center, might easily yield a PR of 1.5 Inches to 1.7 Inches per Hour, however, rotating impact sprinklers in a holding area or field might typically yield a PR of 0.20 Inches to 0.40 Inches per Hour. Table 3 also illustrates the formula and calculations for an Irrigation Run Time of 51.2 Minutes to meet an IR of 0.21 Inches per Day, as calculated in Figure 1, assuming an irrigation system Precipitation Rate (PR) of 0.25 Inches per Hour. This PR would be typical of the full circle impact sprinklers spaced at 40 feet apart, and each one delivering 4.15 Gallons per Minute. Although these irrigation terms are stated in their simplest form, the formulas and calculations demonstrated here can be useful tools in moving away from a “Lots is better” irrigation mentality. By understanding and using these tools, a sound “Irrigation Base Point” can be established, from which appropriate and efficient irrigation management practices can be developed and fine tuned.

**Irrigation Methods**

Three general methods of irrigation are used for routinely supplying water to plants. For fields, the simplest is the furrow or flood method in which water is carried in pipes or ditches and transferred to furrows between rows of plants or the water simply floods the field. This is a very inefficient system for water utilization as more than fifty percent of the water is lost by percolation and evaporation. It is also restricted to fairly level areas. Flood irrigation can also be used for sub-irrigation of containers, however, the area holding the containers must be very level and must have ridges to form a sealed basin to enable flooding the area to a depth of about one inch for a period of about one day per week. Strict management is required for drought tolerant species in this system as root rot can readily develop.

The second and most common irrigation method is overhead irrigation or the use of a sprinkler system. Such a system can vary from a simple lawn sprinkler to a highly mechanized center pivot irrigation system. This system is slightly more efficient than the furrow or flood systems, however, evaporation losses remain high. Initial cost as well as maintenance costs are substantial. Two- to six-inch aluminum pipe, in thirty-foot sections with impact sprinkler heads, are most commonly used in the nursery or in sod farms. Rigid
Table 2. Formula and calculations for determination of a specific **Required Water Source Capacity**, measured in Gallons per Minute (GPM).

<table>
<thead>
<tr>
<th><strong>Formula</strong></th>
<th><strong>Calculation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>[ GPM = \frac{IR \times IA \times 0.623}{\text{Hours} \times 60} ]</td>
<td>[ GPM = \frac{0.21 \times 200,000 \times 0.623}{8 \times 60} = 54.5 \text{ GPM} ]</td>
</tr>
</tbody>
</table>

**Required Water Source Capacity**

- **GPM** = Gallons per Minute Required of Source
- **IR** = Irrigation Requirement in Inches per Day
- **IA** = Irrigated Area in Square Feet
- **Hours** = Hours per Day Available for Irrigation

Table 3. Formula and calculations for determination of a specific **Irrigation Run Time**, measured in Minutes.

<table>
<thead>
<tr>
<th><strong>Formula</strong></th>
<th><strong>Calculation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>[ T = \frac{60 \times ET \times KC}{PR \times AE} ]</td>
<td>[ T = \frac{60 \times 0.20 \times 0.80}{0.25 \times 0.75} = 51.2 \text{ Minutes} ]</td>
</tr>
</tbody>
</table>

**Irrigation Run Time**

- **T** = Time in Minutes
- **ET** = Evapotranspiration in Inches per Day
- **KC** = Crop Coefficient
- **PR** = Precipitation Rate
- **AE** = Application Efficiency

PVC or black polyethylene pipe with pop-up or bubbler heads are most commonly used in the landscape industry. Overhead impact sprinkler heads are commonly used for field and container stock.

The third and most efficient method is the trickle or drip irrigation system. This system and its operation are designed to **prevent water stress rather than correct it**, as is done with the furrow, flood or sprinkler irrigation systems. Water is almost constantly provided at slow and steady rates of 0.5 to two Gallons per Hour under low operating pressures of five to 15 PSI. It is directed only to the root system or part of the root system. Emitters or microtubes deliver the water to the base of each plant. One- to two-inch, low pressure black polyethylene pipe can be used. A pressure reducer and a water filter may be necessary. Costs for this system are moderate depending on the type of emitter used and the need for filtration. Salt build-up can occur in the soil due to the low volumes of water used as these low volumes of water do not provide any leaching of the soil or media. However, turning the system on during a rain will facilitate leaching. Many advantages of the system exist: it is easy and economical to install; water is applied only to the plant area, thereby resulting in fewer weeds; less interference with sales and cultural practices; and less disease incidence. Trickle irrigation is easily mechanized and it promotes better plant growth. Trickle irrigation results in little or no runoff, and evaporation is almost
eliminated. Trickle irrigation is particularly appropriate for landscape plantings. One possible disadvantage of trickle irrigation in the landscape is that the wet zone produced is limited, which can lead to a more compact root system in trees and shrubs. This, however, would be beneficial in a nursery production field as it would provide a greater percentage of roots in the harvested root system.

Soaker hoses provide another form of trickle irrigation. Water slowly seeps through the hose along its entire length. Soaker hoses are particularly useful for rows of plants such as a hedge or in a garden. They may also be used to extend the wet zone around newly planted trees and shrubs. Another variation of the trickle system consists of large donut-shaped bladders or tubs, which can be placed over the root zone of newly planted trees and shrubs. Emitters built into the bottom of the device slowly release a given quantity of water over a period of several hours. The tubs can be filled from a hose irrigation system or from a tank truck. Once the plants are established, the tubs can be removed.

A fourth method of supplying water to plants may be considered, but is seldom used. This method is a container subsurface irrigation or capillary mat irrigation system. It requires a level area for a capillary reservoir and a container media with good capillary conductively. It works best for small containers placed close together. It is very efficient and provides excellent plant growth as no water is applied from above and the plant takes up only as much water as it can use. It allows less weed growth as the growing medium surface is seldom wet. Subsurface irrigation leaches less fertilizer from the containers. It also reduces overhead irrigation damage to open blooms and it leaves no residue on the foliage.

Upon planting or transplanting in the field, landscape, or container, a thorough initial watering is required to collapse large air spaces around the root system. Enough water should be applied to penetrate the depth of the root system if planted in the field or the landscape, or to run out the bottom of the container if container planted. Usually two or more thorough watering applications are required immediately after planting to insure the plant is completely "watered in". If a container medium is high in peat content, allow 30 or 40 minutes between the initial water applications.

The frequency of application and the amount of water to apply depends on factors such as: species, root depth, evapotranspiration rate, soil or media characteristics, relative humidity, temperature, wind, presence of a mulch or cover crop, stage of plant development, exposure, container construction, container size, container spacing, plant size, and type of irrigation system. The frequency and quantity of irrigation will also vary if it is used to regulate vegetative growth and flower response. For field or landscape soils, the procedure of forming a ball of soil as described in Table 4 is helpful to determine the soil moisture level. Container media must be checked by feel or by weight of the container. Field, landscape and container stock can be monitored for moisture stress by observing a few key drought sensitive plant species.

Forsythia, Cornus, Hydrangea, and Potentilla are extremely sensitive to moisture stress and can serve as indicator plants for low moisture levels. By closely observing these species, irrigation needs can be properly anticipated.

Plants in the field or landscape have a much larger reservoir for water storage compared to containerized plants. Plants in the field or landscape may also have better drainage than containerized plants unless a hard pan exists. The bottom of the container creates a "perched water table" which may create an over-watered, low oxygen environment for the root system. The type of soil or media plays an extremely important role in irrigation practices and the irrigator must be aware of such effects. Soil alone cannot be used in container production. Refer to the chapter on Container Production for greater details on this concept.

As water evaporates from a soil or media surface, salts accumulate at the exposed surface. This concentration of salt can be detrimental to plant growth, particularly if it is leached back into the soil or media. To prevent this from occurring, it is necessary to periodically apply large volumes of good quality water to leach salts all the way down and out of the container or down past the root system in the soil. If the soil is a heavy clay, it may be impossible to correct the situation as clay soil may not leach adequately. Also, if the irrigation water is salty or alkaline, leaching will be much less effective.

Each application of water to the field or landscape should be of sufficient quantity to move deeply into the soil. It is important to water deep and less frequently. This will facilitate the movement of salts out of the root zone and it will encourage deep root growth rather than the proliferation of shallow roots caused by frequent shallow watering. Between irrigations, allow the soil to drain thoroughly and dry slightly to facilitate the replacement of oxygen to the root system. On sandy soils, more frequent watering may be required due to the soil’s lower water holding capacity. A general rule of thumb is that for established woody and perennial plants, about an inch of water per week is required.
Table 4. Field determination of soil moisture: Soil Feel Chart. Handle a ball of soil and determine if it flows, crumbles, balls up or ribbons out to obtain an estimate of the available moisture in a coarse, medium or fine textured soil.

<table>
<thead>
<tr>
<th>Percentage of Remaining Available Water</th>
<th>Coarse Textured Soil</th>
<th>Medium Textured Soil</th>
<th>Fine or Very Fine Textured Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% (dry)</td>
<td>Dry, loose, flows through fingers</td>
<td>Powder-dry; sometimes slightly crusted, but easily breaks down into powdery condition</td>
<td>Hard, baked, cracked; sometimes has loose crumbs on surface</td>
</tr>
<tr>
<td>50% or less (low)</td>
<td>Still appears to be dry; will not form a ball with pressure</td>
<td>Somewhat crumbly, but will hold together with pressure</td>
<td>Somewhat pliable, will ball under pressure</td>
</tr>
<tr>
<td>50-100% (good to excellent)</td>
<td>Forms weak ball, breaks easily, will not stick</td>
<td>Forms a ball and is very pliable; sticks readily if relatively high in clay</td>
<td>Easily ribbons out between fingers; has a slick feeling</td>
</tr>
<tr>
<td>Above field Capacity (over-irrigated)</td>
<td>Free water will be released with kneading</td>
<td>Can squeeze out free water</td>
<td>Puddles and free water forms on surface</td>
</tr>
</tbody>
</table>


from both natural and supplemented sources. Again, when irrigating a landscape, water deeply to encourage deep root growth. New plantings, turf, annuals, roses, and some water loving plants may require additional irrigation to maintain good health.

Containerized plants must also be thoroughly watered. However, because these plants are easily stressed, water must be applied more often. It is extremely important that time is allowed for oxygen to be replaced in the media between irrigations to prevent root rot and iron chlorosis of the foliage due to lack of oxygen in the soil. Periodically irrigate until 20% of the applied water drains out of the container. This leaches out any excess salts and prevents salt build-up. Be constantly alert for dry spots as a result of an area being missed by a sprinkler or dry spots due to a plugged or moved sprinkler or emitter. Also, be alert for areas being over watered by overlapping sprinkler heads. Periodic hand watering may be necessary if proper sprinkler coverage is not obtained.

Automatic sprinkler systems are convenient, but not fool proof. Over watering is often a problem. Systems should be turned off during rainy periods. Plants that are subject to saturated soils for long periods of time will sustain root damage. Before the problem is recognized from the top of the plant, the root system could be severely injured or killed.

Timing and monitoring of all irrigation systems is critical. Timers can help in limiting the amount of personal attention needed to maintain crop or landscape, but individual adjustments of an irrigated system may be required when changes in the weather or when plant water needs dictate. Setting a timer to water the same amount every day regardless of the weather, is irresponsible. Irrigation in the early morning is best because the cooler temperatures reduce evaporation, and this allows plant foliage to dry before evening. However, plants are under the most water stress during the heat of the day and need to have adequate water in the soil to accommodate these
periods. In extremely hot weather, supplementary irrigation may be necessary during the day.

The time of year plays a key role in proper irrigation practices. Demand for water will be high in the spring as new growth is expanding. Water consumption will be even higher during the hot summer months when evapotranspiration may exceed the plants capability of water uptake. As fall approaches, water demand is decreased which facilitates proper hardening of the plant. The plant should not, however, be placed under any water stress at this time, as such stress, if severe enough, will actually decrease winter hardening and therefore increase winter injury. After plants have lost most of their leaves in the fall or have reached complete dormancy, a thorough watering will enhance winter survival.

Water quality may be a factor in obtaining optimum plant growth. Water high in salts can be detrimental to root growth by increasing salt levels in the soil or in media to greater than 25 ppm. Excellent to good quality irrigation water would have an electro-conductivity reading of zero to 75 mmhos. Water with a pH greater than 7.2 may be problematic for quality plant growth. Continuous use of such water will increase the pH of the soil or media and subsequently affect the uptake of specific nutrients. Iron uptake is significantly decreased as pH increases.

Water from water softener systems that use sodium ions (Na\(^+\)) to replace the ions that cause hardness should not be used to water indoor or outdoor plants. In some cases, phosphoric acid can be used as a softener and can be used to lower the pH of irrigation water.

Maintenance of any irrigation system must be carefully planned and executed. Maintenance should be completed on all parts of the system during the winter months. The system must be designed and maintained to accommodate the maximum demand during the peak season under the most stressful conditions. An irrigation system in disrepair during a short hot dry period can be devastating.

Irrigation Best Management Practices

Best Management Practices (BMP’s) for Minnesota turf and landscapes have been developed by The Irrigation Association and the Irrigation Industry Committee of the Minnesota Nursery and Landscape Association. These BMP’s were developed to support the design, installation, maintenance and management of landscape irrigation systems that will conserve water and protect water quality. The BMP’s also include proactive Practice Guidelines (PG’s) for landscape irrigation stakeholders to understand, implement and manage efficient irrigation systems. These stakeholders include landscape irrigation designers; landscape irrigation contractors and service personnel; landscape contractors and maintenance personnel; landscape irrigation system owners; water purveyors; state, federal and public agencies; landscape contractors; and related landscape industries and associations. These stakeholders and their responsibilities relative to water conservation and management are described in Table 5 and Table 6. Refer to Appendix A of the MNLA document titled Minnesota Turf and Landscape Irrigation Best Management Practices for additional detail on the issues that each of these stakeholders must confront to achieve improved water resource conservation. The five Turf and Landscape Irrigation Best Management Practices and the corresponding Practice Guidelines to implement the BMP’s, are described below. The Guidelines also serve as templates for establishing specifications that address local needs. Refer to the original Minnesota Turf and Landscape Irrigation Best Management Practices document, hereafter cited as MN T&L I BMP’s, for more detailed information on each specific Practice and Guideline.

Best Management Practices and Guidelines

T&L Irrigation BMP 1: Assure Overall Quality of Irrigation Systems – The purpose of an irrigation system is to provide supplemental water when rainfall is not sufficient to maintain the turf and landscape for its intended purpose. A quality irrigation system and its proper management are required to distribute supplemental water that adequately maintains plant health while conserving and protecting water resources and the environment. Assuring overall quality of an irrigation system requires attention to system design, installation, maintenance and management as described below:

1. Irrigation systems shall be designed to be efficient and to uniformly distribute water.
2. Irrigation systems shall be installed according to irrigation design specifications.
3. Irrigation systems shall be regularly maintained to preserve the integrity of the design and to sustain efficient operation.
4. Irrigation schedules shall be managed to maintain a healthy and functional landscape with a minimum required amount of water.
PG 1: Practice Guidelines for Assuring Quality of Irrigation Systems

a. A qualified irrigation designer or irrigation consultant shall design an irrigation system for efficient and uniform distribution of water based on the requirements of Practice Guideline 2. “Qualified” means certified, formally trained, licensed, or other similar qualification that meets the State of Minnesota and local requirements.

b. A qualified irrigation contractor shall be selected to install the irrigation system based on the requirements of Practice Guideline 3. The irrigation contractor shall test the completed system to verify that the system operates according to the design criteria.

c. The landscape architect, irrigation designer, irrigation consultant, or local water district representative shall perform one or more site observations during system installation to check for adherence to the design. The inspection should insure the installation of the backflow prevention assembly, main line, laterals, valves, sprinkler heads, trickle, drip or micro-irrigation equipment, control wire, controller, and water conservation devices. It should assure that the intent of the irrigation design or consultant has been preserved.

d. Refer to Appendix B of MN T&L I BMP’s for Turf and Landscape General Specifications.

T&L Irrigation BMP 2: Design Irrigation Systems for Efficient and Uniform Distribution of Water – Irrigation systems shall be designed to be efficient and to uniformly distribute water. Specific design criteria include soil type, slope, root depth, plant materials, microclimate, weather conditions, and water source quality, and pressure. To conserve and protect water resources, the irrigation designer shall selected appropriate equipment and components that meet State of Minnesota and local code requirements and site requirements.

PG 2: Practice Guidelines for Designing Irrigation Systems – To ensure that the irrigation system is designed to efficiently and uniformly distribute water, and to conserve and protect water resources, the irrigation designer shall:

a. Obtain direct knowledge of site conditions and not rely solely on plot plans to generate a design.

b. Meet all applicable State of Minnesota and local codes including plumbing and electrical codes.

c. Specify manufacturer, model, type and size of all components to eliminate ambiguity at construction and to facilitate management of the system. The selection of pipe, electrical wire and other materials shall be based on design parameters, environmental conditions and code requirements.

d. Refer to Appendix C of MN T&L I BMP’s for Design Specifications.

T&L Irrigation BMP 3: Install Irrigation Systems to Meet Design Criteria – Irrigation systems shall be installed according to irrigation design specifications. To conserve and protect water resources, the installed components shall meet the irrigation design specifications, manufacturer’s specifications, and State of Minnesota and local code requirements. The installation shall result in an efficient and uniform distribution of water. The irrigation contractor or installer shall be licensed and insured, and certified where applicable.

PG 3: Practice Guidelines for Installing Irrigation Systems – To ensure that irrigation systems are installed to efficiently and uniformly distribute water, and to conserve and protect water resources, the following is required:

a. The Contractor shall procure all permits and licenses, except as otherwise indicated, pay all charges and fees and give all notices necessary and incident to the proper and lawful execution of any and all work. It shall also obtain and supply the owner with all certificates required to show that the work has been performed in accordance with building, plumbing and other authorities and codes; the board of fire underwriter’s; and other like bodies as specifications may require directly or by implication.

b. The Contractor shall acquire the necessary right of way or lawful authority that may be necessary for approved crossings or occupation of any roads, streets or alleys upon which the contract work will be done.
c. The Contractor shall be responsible for all necessary information regarding the exact location of existing underground structures and utilities and shall mark their location at the site.

d. Refer to Appendixes, D, E, and F of MN T&L I BMP’s for Irrigation Installation Specifications.

**T&L Irrigation BMP 4: Maintain Irrigation Systems for Optimum Performance** – Irrigation systems shall be regularly serviced to maintain the performance of the system as designed. To conserve and protect water resources and the environment, the serviced components shall meet irrigation design specifications, manufacturer’s specifications, and State of Minnesota and local code requirements. The maintenance shall sustain an efficient and uniform distribution of water. The maintenance contractor, owner, manager, or irrigation contractor shall be licensed and insured, and certified where applicable.

**PG 4: Practice Guidelines for Maintaining Irrigation Systems** – To ensure that irrigation systems continue to efficiently and uniformly distribute water, and continue to conserve and protect water resources, the maintenance contractor, owner, manager, or irrigation contractor shall:

a. Establish a periodic maintenance schedule for inspection and reporting performance conditions to the end-user or owner of the irrigation system.

b. Report any deviation from the original design.

c. Create a station or zone map for ease of system inspection and controller programming.

d. Periodically review the system components to verify that the components meet the original design criteria for efficient operation and uniform distribution of water.

e. Ensure that the replacement hardware used for system repairs matches the existing hardware, and is in accordance with design. Aftermarket replacement nozzles must match original parts well enough to preserve distribution uniformity and the precipitation rate.

f. Conduct a performance audit every three to five years to assure that the system is working efficiently and with the desired Distribution Uniformity for Lower Quarter and Precipitation Rate specifications.

g. As plant material matures, trim or remove vegetation as required to preserve system performance. Add additional sprinklers or other hardware as required to compensate for blocked spray or changes in the irrigation needs of the landscape. Ensure that system modifications are in keeping with the design specification and do not cause landscape water demand to exceed the hydraulic capacity of the system.

h. Establish a “winterization” protocol and a corresponding process for system activation in the spring.

**T&L Irrigation BMP 5: Manage Irrigation Systems to Respond to Changing Water Requirements in the Landscape** – To conserve and protect water resources and the environment, irrigation schedules shall be changed as required to provide supplemental water to maintain a functional and healthy turf and landscape with the minimum required amount of water.

**PG 5: Practice Guidelines for Managing the Use of Irrigation Water** – To conserve and protect water resources and the environment, irrigation schedules shall be changed as required to provide supplemental water to maintain a functional and healthy turf and landscape with the minimum required amount of water. To facilitate managing irrigation water consumption, irrigation managers, consultants, end-users, owners, maintenance personnel, and contractors shall:

a. Create a site map showing, at a minimum, the location connection of each water meter, backflow prevention device, controller, station or zone valves, and the landscape area served by each valve.

b. Ensure that a dedicated irrigation water meter has been installed for measuring both the irrigation water flow rate and the volume applied to the landscape.

c. If necessary, perform an irrigation audit to obtain data for creating a base irrigation schedule.

d. After the system has been placed into service, evaluate the effectiveness of the system’s water management by monitoring and comparing actual landscape water usage to a target design irrigation water budget.
e. Periodically, verify that sensors and other components in the irrigation system are working properly. Inspect the irrigation system during operation.

f. Periodically, visually confirm that the plant material is healthy and that soil moisture is adequate. Use a soil probe to evaluate root depth, soil structure and soil moisture.

### Underground Irrigation Procedural Specifications

**Scope of Work** – Contractors bidding a project must submit proof of three jobs of this type and size in order to be an acceptable contractor. Also see Contractor Qualification section below. The work contemplated by these specifications consists of all required labor, material, equipment, and services. Unless otherwise specified, the plans and specifications are intended to include everything requisite and necessary for proper installation and completion of the work, whether each necessary item is mentioned herein or not. The plans and specifications are intended to be cooperative: any item called for in one and not the other, shall be as binding as if called for in both. All contractor alterations to plan details or specifications must be approved by the Owner and a consultant, in writing, a minimum of two weeks prior to bid opening; if this is not accomplished, the contractor’s bid may be disqualified.

**Description of System** – Layout of the irrigation system shall be provided on a detailed drawing.

**Examination of Site** – Submission of a bid by a Contractor shall be considered evidence that an examination of the site has been complete as well as the acceptance of the plan, details, and specifications by the contractor.

**Commencement and Completion** – The successful bidder must agree to commence work on or before a date to be specified in a written “Notice to Proceed” document, and to fully complete the work within the number of calendar days shown on the bid form. Completion time, expressed in consecutive calendar

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Responsibilities Relative to Water Conservation and Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water Purveyor</td>
<td>1. Document beneficial and reasonable uses of water. 2. Promote the adoption and use of reclaimed water. 3. Establish educational programs and material for users of irrigation systems. 4. Maintain desired water pressure in mains and sub-mains. 5. Use and maintain water meters. 6. Reduce chemical movements. 7. Reduce runoff and off-target irrigation.</td>
</tr>
<tr>
<td>1. Irrigation Designer, Consultant, or Engineer 2. Irrigation Contractor or Installer 3. Maintenance Contractor 4. Owner or End-user of Irrigation System 5. Landscape Contractor 6. Water Purveyor</td>
<td>1. Assure overall quality of the irrigation system. 2. Design the irrigation system for the efficient and uniform distribution of water. 3. Install the irrigation system to meet design criteria. 4. Maintain the irrigation system for optimum performance. 5. Manage the irrigation system to respond to changing water requirements in the landscape. 6. Reduce runoff and off-target irrigation.</td>
</tr>
<tr>
<td>1. Landscape Contractor 2. Nursery and Landscape Retail and Wholesale Companies</td>
<td>1. Optimize turf and landscape fertilization. 2. Reduce biomass. 3. Inform owners about water efficient landscape practices.</td>
</tr>
<tr>
<td>1. Nursery and Landscape Retail Companies 2. Nursery and Landscape Wholesale Companies</td>
<td>1. Characterize plants for less water use: native plants, xeriscape plants and others. 2. Identify turf species that use less water.</td>
</tr>
</tbody>
</table>
days, will be converted to a specific date at the time the notice to proceed is issued. Should it be found impossible to complete the work on or before the time specified, a written request may be substituted for extension of time; otherwise a “delay of project” fee may be assessed up to $100.00 per day. It the owner finds that the work was delayed because of conditions beyond the control of the Contractor, an extension of time may be granted for completion as appears reasonable and proper.

**Conduct of Work** – The Contractor shall maintain a skilled foreman on the site during the entire installation process. The foreman shall have the authority to act for all matters pertaining to the work. The Contractor shall be responsible for coordination of all work with other trades. The Contractor shall confine operations to areas to be improved and to areas allotted for materials and equipment storage.

**Handling of Materials and Equipment** – The Contractor shall provide and pay for transportation of all material and equipment delivered and removed from the site.

**Contractor’s Responsibility** – The Contractor shall be responsible for all work, to include subcontractors and every part thereof and for all materials, tools, and property of every description used in connection therewith. The Contractor shall protect the Owner against all liabilities, claims or demands for injuries or damages to any person or property growing out of the performance of the work under this contract.

**Contractor Qualifications** – As a prerequisite of qualification to bid, the irrigation construction company shall provide verifiable documentation that such person or company is licensed by the Minnesota State Board of Electricity as a Technology Systems

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**Table 6. State, Federal and Public Agencies responsibility relative to Water Conservation and Management.**

<table>
<thead>
<tr>
<th>Agency</th>
<th>Responsibilities Related to Water Conservation and Management</th>
</tr>
</thead>
</table>
| State, Federal, and Public Agencies (General)| 1. Watershed protection.  
2. Integrate water agency involvement in Land Use Planning.  
3. Reduce runoff and off-target irrigation.  
4. Reduce chemical movements.  
5. Optimize turf and landscape fertilization.  
6. Reduce and manage grass clippings. |
| State and Federal Environmental Regulatory Agencies | 1. Non-point source pollution of water resources.  
2. Water and water quality information.  
3. Regulations for using treated effluents.  
4. Information on base level evapotranspiration. |
| Public Agencies (Parks, etc.)               | 1. Maintain public irrigation systems.  
3. Maintain an inventory of irrigation systems. |
| Municipal and Rural Water Departments and Companies | 1. Insure adequate water supplies to meet demands.  
2. Regulate and enforce local regulations. |
2. Register professional engineers, licensed irrigation designers, consultants, landscape architects, and contractors.  
3. Coordinate continuing education programs. |
2. Irrigation technology, crop varieties, irrigation management, and water quality research.  
2. Sustain and protect natural resources.  
3. Coordinate local conservation district programs. |
Codes and Inspection – The entire installation shall comply with all local and state laws and ordinances and with all the established codes applicable thereto. The Contractor shall take out all required permits, arrange all necessary inspections and shall pay any fees or expenses in conjunction with the work under this contract.

Owner Supervision – The Owner assumes no responsibility in the supervision and inspection of the execution of this contract beyond ensuring, to the Owner’s satisfaction, that the plans and specifications are being properly interpreted. This supervision and checking will not relieve the contractor of any responsibility for the performance of work in accordance with the plans and specifications.

Cleaning Premises – The Contractor shall at all times keep the premises on which the work is being done, and the adjoining premises, clean of rubbish caused by the work on this project. Upon completion of the job, the Contractor shall clean up all debris and leave the job in a neat and clean condition.

Instructions – After completion of the project, the Contractor shall instruct the Owner and the Owner’s personnel in the proper operation and maintenance of the system.

As-Built Plan – After completion of the installation, the Contractor shall provide a reproducible drawing showing all sprinkler heads, valves, and piping to scale with dimensions where required.

Catalog and Specification Data – The Contractor shall assemble two sets of catalog and specification data including instruction for installation, operation, spare parts list and care of all equipment furnished under this contract. This data shall be bound in a three ring binder of appropriate size. The two binders shall be hand delivered to the Owner upon conclusion of the work.

Seasonal Drainage – Seasonal drainage shall be done by the “Blow-out-Method” which replaces the water with compressed air. The Contractor shall provide the first year blow-out at no cost to the Owner.

Guarantee – The Contractor, for a period of one year from final acceptance, shall promptly repair or replace, at no cost to the Owner, any and all parts which prove to be defective from manufacturer or workmanship.

Acceptance – Before final acceptance is made, the Contractor must have in writing from the Owner and Consultant, that the system meets top quality installation and these specifications have been executed 100%.

Under Ground Irrigation Materials Specifications

Materials Specifications – All materials and equipment furnished under this contract shall be new. Sprinkler heads, electric valves, and automatic controllers shall be made by the same manufacturer. Sprinkler heads, electric valves and automatic controllers shall each have a two-year product, not including labor, manufacturer warranty. All products listed must be installed to the manufacturer’s warranty. Any product submitted as an equal must be approved by the Owner and Consultant two weeks prior to the bid opening.

Polyvinyl-Chloride Pipe (PVC) – All 1-1/2-inch and larger pipe shall be virgin, high impact, polyvinyl chloride (PVC) pipe, having a minimum 160 PSI working pressure rating. All PVC pipe shall be continuously and permanently marked with manufacturer’s name, material, size and schedule or type. Pipe shall conform to A.S.T.M. (American Society for Testing and Materials) standards D2241 and D2672 or the latest revision. Materials shall conform to all requirements of A.S.T.M., D1784, or the latest revision. A two-step gluing process must be used including purple primer and blue glue.

Polyethylene Pipe – All pipes 1-1/4-inch and smaller pipe shall be flexible non-toxic polyethylene pipe made from 100% virgin material meeting N.S.F. (National Sanitation Foundation) standard #14 for use in pressure potable water applications, for 800 design stress. All sizes shall have a minimum 80 P.S.I. working pressure rating. All polyethylene pipes shall be continuously and permanently marked with the manufacturer’s name, material, size and schedule. Pipe shall conform to
Polyethylene Pipe Fittings – Plastic type PVC or nylon insert fittings and/or brass saddle tees, where applicable, shall be used. All main line connections shall be double clamped. All clamps shall be stainless steel worm gear type or stainless steel crimp clamps.

Electric Control Valves – Valves used in an electrically controlled automatic system shall be a globe or angle configuration with female pipe thread inlet and outlet. Valves shall have a manual flow control, with an external and internal bleed to manually turn on. For valve size and location, refer to an illustrated plan.

Valve Boxes – Valves boxes shall be a plastic 12-inch rectangular box, or a six- or ten-inch round box, all with covers. Any electric valve, manual valve, major wire splice, or future expansion wires shall be installed in a valve box.

Sprinkler Heads – Sprinkler heads shall have fixed sprays and gear driven rotors. Gear driven rotors shall be pop-up-style with full and part circle, interchangeable nozzles, 30 feet to 50 feet radius, and a radius adjusting screw. Fixed spray sprinklers shall be pop-up style with MPR nozzles providing a five feet to 15 feet radius. For sprinkler head type and location, refer to an illustrated plan.

Swing Joints – Every sprinkler head and quick coupling valve with one-inch threads shall be mounted on a one-inch, three-elbow manufactured O-ring swing joint. All swing joints for Quick Coupling Valves shall have a brass insert and brass nipple. All ½-inch and ¾-inch threaded sprinklers may be mounted to pipes using a cut-off riser or swing pipe and fittings.

Communication Circuitry – Electric control wires shall be #14 gauge single strand wire. Where instructed, extra wires shall be stubbed in from the controller to each expansion area shown on the plan. Electric control wires shall be direct-bury wire manufactured for irrigation system use. All multiple valves operating on one zone shall have its own wire from the controller. Any future wires stubbed from initial installation must run from the controller to the approximate location shown on the plan, and installed in a valve box. Future wires shall be a different color from initial installation. Six to ten feet of extra wire shall be left at controller and valve box location. For wire type and location, refer to an illustrated plan.

Automatic Controller – Automatic controllers shall be 12-, 15-, 18-, 24-, 36-, or 48-station, plastic or metal cabinet, 365-day clock calendar, zero- to ten-hour station run-times per station in one minute increments, seasonal adjustment from zero to 200% in ten percent increments, and have heavy duty MOV’s for protection from surges. For controller type and location, refer to an illustrated plan.

Quick Coupling Valves – Quick coupling valves shall be one-inch threaded with one-inch key opening, standard cover series. For quick coupler type and location, refer to an illustrated plan.

Backflow Preventer – A reduced pressure backflow preventer or a pressure type backflow preventer is required. Type used is to be determined by the location of the water supply and sprinkler locations on the site. For backflow type and location, refer to an illustrated plan.

Manual Valves – Manual valves shall be the bronze gate type. Manual valves shall be sized according to the line size they are being installed on. For manual valve type and location, refer to an illustrated plan.

Booster Pump – Booster pumps shall be an end suction centrifugal type using single phase, 230 volts. The contractor and designer shall be responsible to properly size and provide, if necessary, a booster pump as determined by site conditions.

Pump Starters & Relays – Pump starters shall be of a style with adjustable solid state overload, amperage reset, and a 24-volt coil, using a NEMA 1, 230-volt three-phase starter.

Radio Remote – A radio remote shall be a complete multi-station kit with a hand held radio, receiver, charger, and carrying case.

Rain Switch – Rain sensors shall be of a technology that inhibits or interrupts the operation of the irrigation system during periods of sufficient moisture. They shall be adjustable and include a manual by-pass switch.

Enclosure – Enclosures shall be 14-gauge steel with weatherproof cover and hinge. They shall be approximately three feet by three feet by five feet in size.

Subsurface and Drip Emitter – Subsurface piping shall be “X” GPH and “X” spacing of drippers along pipe. All components including flush valves, air or vacuum relief valves, pressure regulating valves, filters, check valves, system operation indicator, and fittings, shall be installed as shown on the irrigation plan. Drip emitters shall be pressure compensated and available in 0.5 GPH, 1.0 GPH, and 2.0 GPH outlets.
Underground Irrigation Installation Specifications

Permits, Licenses and Certificates – The Contractor shall procure all permits and licenses, except as otherwise indicated; pay all charges and fees, and give all notices necessary to the proper and lawful prosecution of the work. The contractor shall also obtain and supply to the Owner, all certificates required to show that the work has been performed in accordance with the building codes, plumbing codes, and other authorities, as well as the Board of Fire, Underwriter’s, or such other like bodies, as the specifications may require directly or by implication. When the work performed affects the property or facilities of public utility or other corporations, or of private persons, the Contractor shall obtain and supply from such corporations or person if required, statements that the work has been performed satisfactorily so far as their interests are affected and that all claims, therefore, have been settled by the Contractor.

Rights of Way – The Contractor shall acquire the necessary right of way or lawful authority that may be necessary for approved crossings or occupation of any roads, streets, or alleys upon which the contract work will be done.

Underground Structure – The Contractor shall be responsible for all necessary information regarding the exact location of existing underground structures and utilities and shall mark their location, at the site. The Contractor shall be liable for the damages to, and the cost of repairing or replacing any buried conduit, cables or piping encountered during the installation of the work, unless they were not marked, or the Contractor was not previously informed of such underground utilities. If the Contractor is aware of such utilities, the Contractor shall immediately have the incurred damages repaired at the Contractor’s own expense. Conversely, the Owner shall be liable for the cost of repair to any existing utilities of which the Contractor had not been previously informed.

Excavating and Backfilling – The Contractor shall do all necessary excavation required for the proper installation of the work. When backfilling, all backfill material shall be free from rock, large stones, or other unsuitable substances that may damage the pipe. Backfilling of trenches containing plastic piping shall be done when the pipe is cool to avoid excessive contraction. All backfill material will be compacted in six-inch layers to grade to insure that no settling results.

Pipe – All main line pipe or pipe constantly under pressure, or 2-1/2 inches and larger, shall be installed to a minimum depth of 18 inches to 24 inches. Lateral pipe or pipe located after electric valves, shall be installed to a minimum depth of 12 inches to 18 inches. Piping shall be capped and secured at the end of each work day to prevent entrance of foreign material, and to prevent damage to or rising of the pipe. All piping shall be flushed of construction material.

Wire – Minnesota state law requires that all low voltage wiring shall be installed and maintained by a company that holds a Technology System Contractor license, and employs a person that holds a Power Limited Technician license. Irrigation wire shall be installed in the same trench as the main line piping. At each electric valve connection, a minimum of two feet of slack wire shall be provided to facilitate future service. All wire splices shall be located with-in a valve box, or in a separate box. All underground splices shall be waterproofed with wire connectors and a Direct Burial Splice Kit (DBY).

Sleeving – Pipes and wires crossing under roads, walkways, curbs, permanent fixtures, etc., shall be enclosed in PVC sleeving with class 160 PVC as a minimum rating. Sleeving depth shall be a minimum of 18 inches and a maximum of 24 inches under items crossed. All sleeves shall extend beyond the edge of paving or construction by a minimum of 12 inches.

Rock Excavation – Rock excavation in the alignment and depth shown on the plan shall be adjusted if at all possible to avoid excavation. If alignment and depth adjustment cannot be made and it becomes necessary to remove the same, the Contractor shall be paid for all additional costs incurred in the handling of the material excavated. The Contractor must show the Owner or Consultant the problem encountered and receive verbal and written approval before any add-on monies will be allowed.

Water Supply – The irrigation contractor shall verify prior to bid, the location and pressure of the water source. The water source shall be on the discharge side of the backflow prevention device and a meter shall be on the exterior of a building wall. The appropriate backflow prevention device, although installed by others, is to be supplied by the irrigation contractor. The source shall be taken from appropriate location shown on an irrigation plan.

Backflow Prevention Assembly – All potable water sources shall be protected by appropriate backflow prevention devices. Water used for irrigation is considered hazardous, therefore, no water intended for human use or consumption may be tapped into the irrigation system after the backflow preventer.
**Controller** – The controller shall be mounted in an appropriate location as shown on the plan. The controller shall be wired direct in conduit with a manual on/off switch mounted under the controller.

**Electrical** – The Owner shall provide a 120 volt, 15 amperage circuit into the controller location. The irrigation contractor shall be responsible for the controller hook-up as specified.

**Electric Valves** – Electric valves shall be installed in either the globe or angle position, and they shall be installed in valve boxes of sufficient size to allow easy access without excavation of the valves. All wire splices must use an approved water tight splice, such as DBY epoxy pack.

**Valve Boxes** – All valve boxes shall be supported in the ground by using paver style bricks in every corner or side. Follow valve box details on a plan for installation directions. Provide sufficient clearance between the valve box cover and the automatic valve to prevent damage if the valve box is driven over. Wood supports of any kind are not allowed.

**Improperly Operating or Located Equipment** – Any equipment which fails to operate properly and/or is located incorrectly shall be promptly corrected or relocated at the Contractor’s expense. If the Contractor wishes to make any field changes, written permission must be received from both the Owner and Consultant.

**Thrust Blocks** – Thrust blocks shall be provided at all changes in size or direction of mainline piping. Elbows, reducers, plugs, and the opposite side of tee branches all require thrust blocks. Concrete thrust blocks are constructed by pouring concrete between the fittings and the undisturbed bearing wall of the trench.

**Additional Uses of Irrigation Systems**
Although the most direct and apparent use of an irrigation system is to provide moisture for survival and growth of nursery and landscape plants, it also has several other functions. These include: leaching of accumulated salts or over-applied fertilizers from soil or media, application of water-soluble fertilizers, frost protection, moistening of soil to facilitate planting or digging operations, sealing of volatile soil fumigants, incorporation of herbicides, reducing transpiration and the application of pesticides and growth regulators.

The effective and efficient use of an irrigation system will increase the overall growth potential of plants to enhance the landscape and improve the management and profitability of plant production.
Sample of Installation Details

Recommended Installation Instructions: Spring-Type Sprinklers

1. The *(insert spray head name & type)* is available in a four-inch, six-inch, or 12-inch pop-up head with a standard cap, seal, and nozzle parts.

2. Fixed sprays are used in many applications and thus several installations are possible.

3. For areas bordering hardscape features such as sidewalks, it is recommended that sprinklers be mounted on either swing joints or flexible poly pipe. The use of such mounting will allow lateral movement of the sprinkler without incurring damage in those areas where maintenance operations and traffic patterns may logically be assumed.

4. The use of swing joints *(insert swing joint name) (or approved equal)* will also accommodate the mounting of six-inch and 12-inch heads without the necessity for deep trenching.

5. *(Insert swing joint name)* swing joint Pipe and fittings are rated at 400 PSI burst and may eliminate any clamping requirements.

6. Fixed spray heads are often mounted on fixed risers. Such installation is appropriate for shrubs, ground covers, or other areas where traffic or vandalism is not perceived to be a problem. The 12-inch high pop-up model may prove to be of particular benefit in areas of ivy, higher shrubs, or where long range maturity will produce taller plants. Both pop-up and fixed spray heads should be placed perpendicular to finished grade for optimum performance.

7. All *(insert spray head name)* heads flush only upon retraction. Not having a flush during pop-up allows the maximum number of sprinklers to be used in accordance with the hydraulic capabilities of the zone. flushing during retraction clears debris from around the riser, therefore preventing scoring of the riser and ensuring positive retraction.

8. All *(insert spray head name)* sprinklers will accept *(insert nozzle type)* nozzle. Thus, in a pop-up sprinkler mounted at grade, it is possible to specify flood bubbler, stream bubbler, stream spray, micro spray, special pattern, adjustable arc, or any standard *(insert nozzle type)* nozzle. This ability to mix and match allows specification of any odd shape or standard sprinkler pattern with full confidence. It also allows system designs that reduce liability potential through the use of pop-up sprinklers in areas, that have traditionally been covered with fixed risers and often reinforced with rebar.

9. In areas of high pressure, 31-75 PSI or more, pressure compensating nozzles and/or screens shall be used. The use of pressure compensating nozzles ensures that each nozzle is performing at its optimum pressure of 30 PSI. This standardizes performance along long laterals where elevation differences occur and will prevent fogging due to high pressures. Fixed sprays do not need to be mounted directly next to sidewalks, buildings, or other hardscape features. Placement of these heads two inches to three inches away from such features will allow normal maintenance procedures and still accommodate “at head” watering.
Sample of Specific Installation Details

Recommended Installation Instruction: Rotor-Type Sprinklers

1. The *(insert rotor sprinkler name)* sprinklers are designed to provide maximum performance and versatility for medium range turf and ground cover areas, performing in the 20 feet to 52 feet radius range.

2. Pop-up and high pop-up versions of the *(insert rotor sprinkler name)* are mountable at grade. It is recommended that they can be mounted on swing joints or on flexible poly pipe, particularly in areas where pedestrian traffic is expected or where normal maintenance operations such as mowing will occur. Swing joints should be specified as triple swing joints, allowing movement up and down, laterally, or at an angle to the plane of installation. *(Insert swing joint name and Model)* and adapters are rated at 400 PSI burst and may eliminate the use of some clamps.

3. High pop-up versions allow full 12 inches of pop-up and may be of considerable value in flower beds, low shrubs or ground covers to clear the plant material.

4. The *(Insert rotor sprinkler nozzle type and name)* nozzles are engineered to provide a smooth, consistent curtain of water across the arc. Provision is made for “at head” coverage. Accordingly, it is recommended that sprinklers be located two inches from walks, curbs, hardscaping, mow strips, header boards, and edges of lawn. In addition, sprinklers should be placed six inches to 12 inches from buildings. Such location will allow normal maintenance procedures such as mowing to be accomplished, and it will also minimize spray on buildings.

5. Normal “at head” spray as well as capillary movement of the water will ensure adequate coverage when backspaced.

6. All rotor sprinklers are supplied with a radius adjustment screw which allows 25% reduction to fill in irregular areas. This radius reduction does not reduce flow and a balance in precipitation rates is maintained. Thus, any combination of arcs can be valved together as long as the basic balancing scheme is adhered to, potentially saving both valves and controller stations.


8. Blank.

9. Spacing of heads shall not exceed manufacturer’s maximum recommendations.

10. Matched precipitation will be required on all sprinklers operating on the same zone.

11. Conform to manufacturer’s specifications concerning diameter of throw and gallonage at given pressures.