City of Bozeman Subsurface Drip Irrigation Design Guide

12/5/2024

Introduction

In 2024, the City of Bozeman adopted a Water Efficient Landscape Ordinance (WELO) and associated Landscape and Irrigation Performance and Design Standards Manual (Manual). These regulations will save millions of gallons of water over the coming years by requiring water-efficient landscape and irrigation design in new development projects. A key area of focus in the Manual is irrigation efficiency. One of the most efficient ways of delivering water to turfgrass is through subsurface drip irrigation. Dripline or drip pipe, with integrated inline emitters is installed directly in the plant's root zone so that almost no water is lost to evaporation or runoff. The Manual encourages the installation of drip irrigation by designating a higher efficiency factor for drip than for overhead spray irrigation, which is typically used to irrigate turfgrass.

The use of subsurface drip irrigation has been limited in our community to date. Creating efficient subsurface drip irrigation systems is easy if designed and installed properly. The City of Bozeman has created this Subsurface Drip Irrigation Design Guide to assist designers and contractors in designing and installing efficient subsurface drip irrigation systems.

Primary considerations

1. Plant type and root depth
    - Plant root depth varies among plant species. Subsurface drip is most commonly used in turfgrass areas due to its high efficiency. The average root depth for Kentucky Blue Grass is four to eight inches. As such, subsurface drip irrigation used for turfgrass areas should be installed at a depth of six inches. This depth will ensure that the appropriate amount of water is applied to the plant material's root zone while keeping the dripline deep enough to avoid potential damage that can occur during core aeration or power raking.

2. Soil type and infiltration rate
    - Soil type will affect the infiltration rate of the soil. Soil in Bozeman generally contains high percentages of clay resulting in low infiltration rates. When beginning the design process for a subsurface drip irrigation system, it is important to first perform a soil texture test to understand the soil's infiltration rate. Refer to Appendix B for methods of performing a soil texture test.

Table 1: Simplified infiltration rates based on soil texture

Soil	**Textural categories**	**Basic infiltration rate (in./hour)**
Coarse	Sand, loamy sand	1.00
Moderately Coarse	Sandy loam	0.50
Medium	Loam, silt loam, silt	0.40
Moderately Fine	Sandy clay loam, clay loam, silty clay loam	0.15
Fine	Sandy clay, clay, silty clay	0.10

3. Dripline and emitter spacing
    - Subsurface drip irrigation utilizes a type of drip irrigation commonly called dripline. Dripline is the polyethylene pipe that is commonly used in irrigation systems, but has emitters installed at specific intervals. When selecting dripline products, the best emitter spacing and emitter flow rate for the project will need to determined. Emitters can be spaced between six inches to two feet depending on the manufacturer, product and desired precipitation rate. Emitter flow rates can range from 0.4 gallons per hour up to one gallon per hour. The emitter spacing and flow rate, along with the dripline row spacing, will give you the information needed to determine the zone's overall flow rate.

Formula to calculate the total flow rate of a drip zone:

$$F = \frac{\left(\frac{D}{ES}\right) x EF}{60}$$

F = Total flow in gallons per minute, D = Total length of dripline in the zone (feet), ES = Emitter Spacing (feet), EF = flow rate of a single emitter (gallons per hour)

- The flow of a zone should never be greater than what the point of connection is able to provide. Determining the overall flow rate of the zone will give you the information needed to determine the precipitation rate of the zone.

Formula to calculate the precipitation rate of a drip zone:

$$PR = \frac{96.3\ x\ Q}{A}$$

A = physical area of zone (ft^2), Q = total zone flow (gallons per minute), PR = precipitation rate of zone

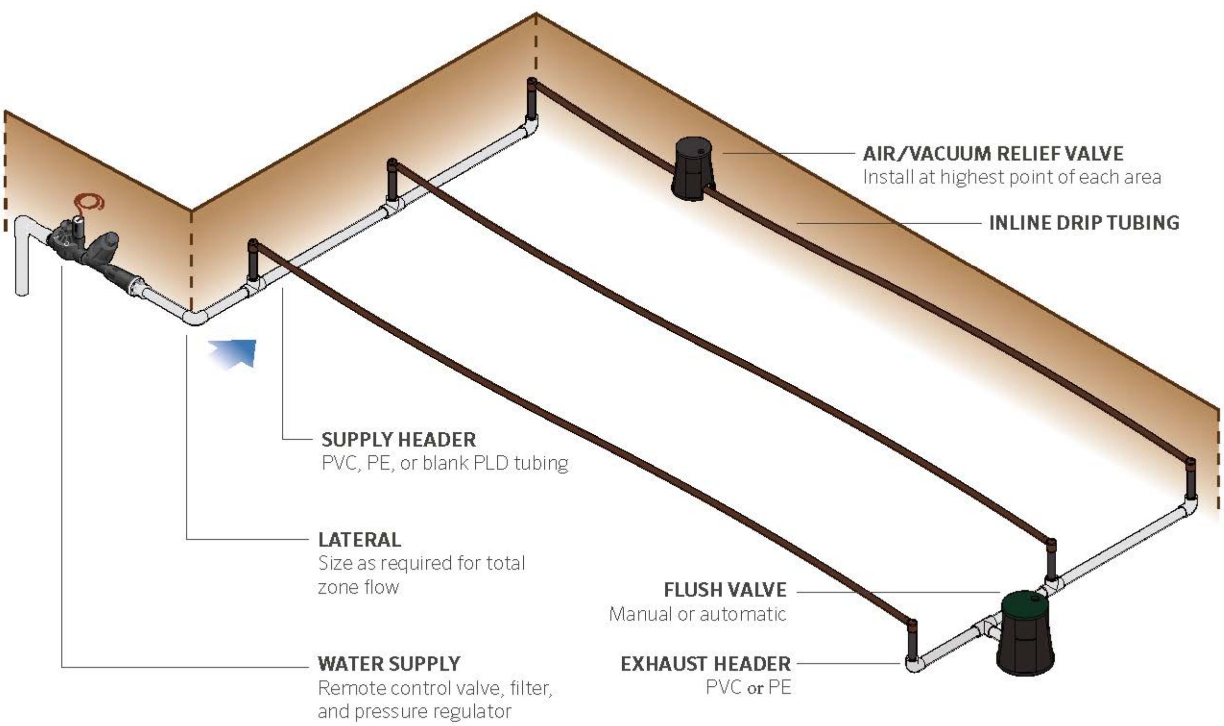
- When designing an irrigation system, the precipitation rate of the zone needs to be the same or lower than the infiltration rate. If the precipitation rate is higher than the infiltration rate, the water will go to waste. Because Bozeman has clay-heavy soils, it may not always be possible to keep the precipitation rate lower than the infiltration rate. In this case, it is recommended to institute a cycle-soak-style program to avoid wasting water.

4. Layout style of the zone
    - Considering the layout of the dripline is important to achieve required flow and pressure. There are two common designs for subsurface drip irrigation zones; end feed and center feed layouts. Areas with curved edges are also important to consider in the zone layout.
        - For improved flow and pressure in each zone, it is best to minimize the length of the dripline runs while maximizing the length of the supply and exhaust headers. This is because the header pipes experience less pressure loss than the dripline due to the size of the pipe.
        - It is best practice to install subsurface drip irrigation 4” from hardscape surfaces.

- End feed layout can be best described as the supply header for the zone being one of the borders of the zone. This means that the dripline is being fed from one side or end of the zone. In the figure below, you can see that the valve is feeding the zone from the left side. This creates longer runs of dripline, which will result in pressure loss and can lead to a lower distribution uniformity.

End-Feed Layout

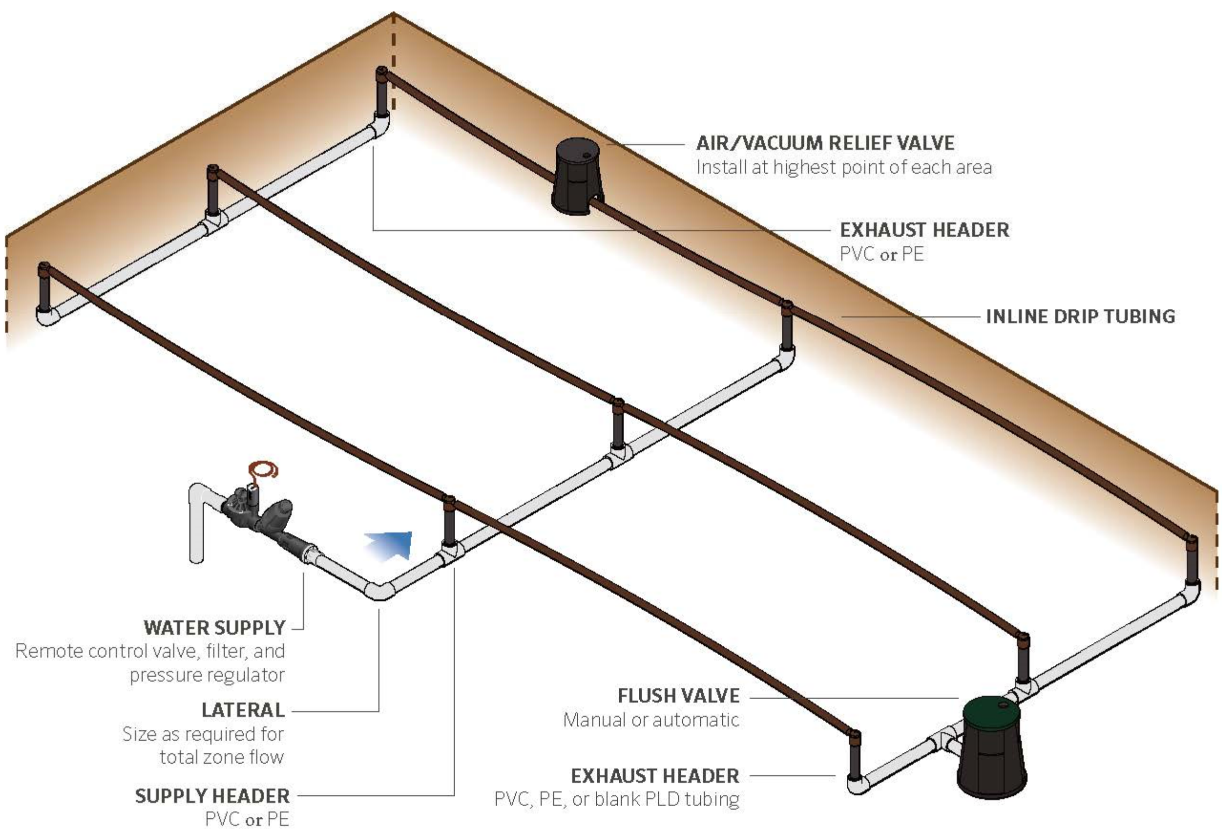
End-feed headers typically reduce piping costs and labor for smaller areas. Use end-feed layouts for sloped zones with the supply header located above or at the top of slope.



- Center feed layout can be described as the supply header for the zone bisecting the zone's geographical area. This means that the irrigation zone is being fed from the middle. By running the supply header directly through the middle of the area to be irrigated, the length of dripline runs will be shortened. This will result in better pressure and flow throughout the zone. Because dripline uses .5” pipe, it experiences higher losses in pressure when compared to larger pipe sizes typically used in overhead irrigation. To counter potential issues that can arise from a loss in pressure, it is a best practice to use a center feed layout whenever possible.

Center-Feed Layout

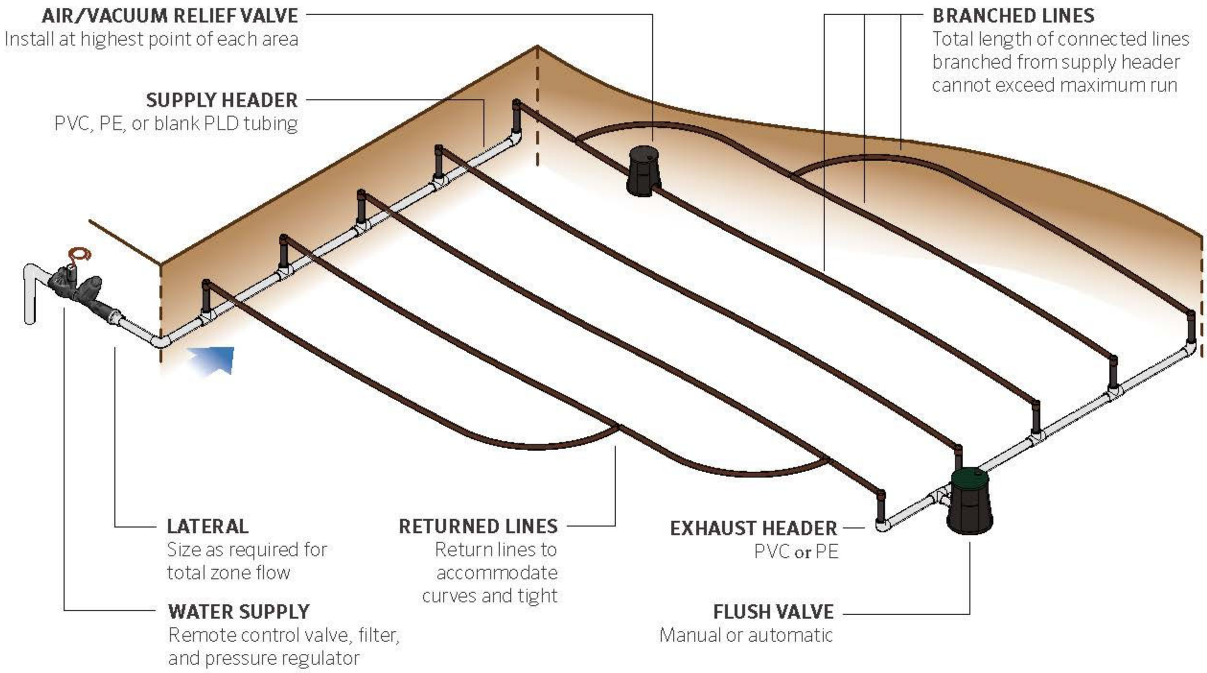
Center-feed layouts allow larger areas to be served with one zone and maximize the length of a zone. This is ideal for medians or parkway strips. Center-feed layouts require exhaust headers at each end.



- Edge conditions, including irregular shapes and areas with curved edges, should be considered. Achieving head to head coverage, matched precipitation rates, and avoiding overspray are all significant challenges when designing overhead spray zones for areas that are not simple squares or rectangles. For this reason, subsurface drip irrigation provides an opportunity to irrigate these areas in the most efficient manner possible.

Edge Conditions

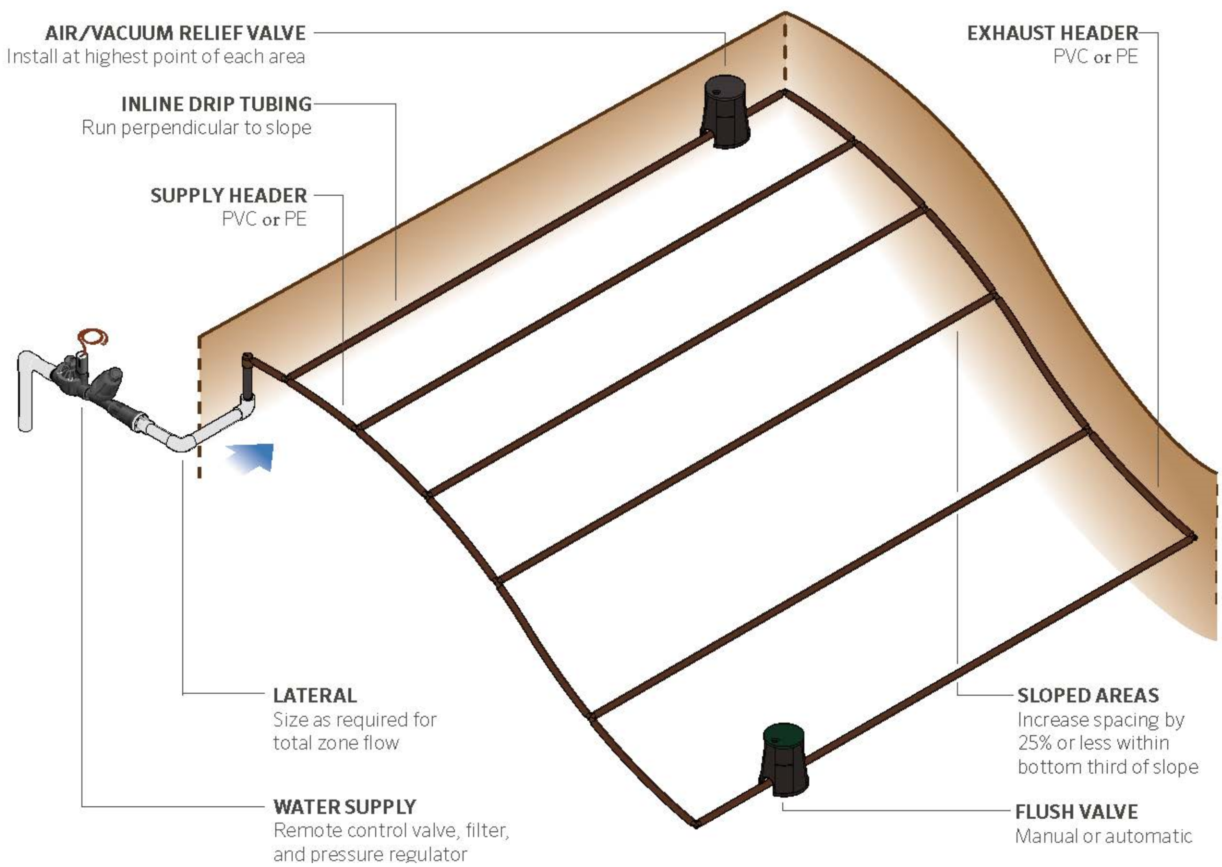
Follow curves and irregular shapes by "branching" to either terminate or extend inline drip tubing rows. When extending, be sure to add each branched row to the total length of the original row connected to the header and not to exceed the maximum length allowable.



  - When designing zones for areas with curved edges, it is better to have more of the distribution pipes return than branch (see image above. Branching lines will lead to more pressure loss as the total length of branched lines must be counted as a single run.

5. Elevation changes
   Changes in elevation affect the zone's pressure and ability to maintain uniform distribution. Sloped areas warrant special consideration when designing subsurface drip irrigation systems.
   - Most dripline manufacturers produce products with integrated check valves. These check valves prevent the water in a zone from flowing out of the lowest elevation emitters after the zone has completed its cycle. This can lead to over watering of the lowest elevation area within zones. To avoid this, it is a best practice to use dripline with integrated check valves in zones that are on sloped areas.
   - When installing dripline on a slope, the piping should be laid so that it is parallel to the contours of the slope. The dripline should run across the slope whenever possible instead of up and down the slope.
   - Due to gravity's influence on water to move down slope, it is a best practice to space the dripline at the bottom of the slope farther apart than at the top of the slope. Over the top ⅔ of the slope, space the dripline, as the manufacturer's chart suggests. Over the bottom ⅓ of the slope, space the dripline roughly 25% further apart than what is indicated on the manufacturer's chart. If manufacturer guidelines differ from those in this design guide, use the manufacturer's recommendations for the specific product.

NOTES: *Make sure anti-siphon, atmospheric or pressure vacuum breaker assemblies are at least 12" above the highest emitter. Consult local codes for installation methods, approvals, and guidance.*



6. Air/vacuum relief valves
   - Because subsurface drip is located entirely underground it is much easier for emitters to become clogged or pipes to be crushed from a vacuum. To avoid these potential issues, subsurface drip irrigation zones should be installed with a vacuum relief valve.
   - Vacuum relief valves are not required in zones that utilize dripline equipped with integrated check valves, which prevent water from draining out at the lowest point. Therefore, no vacuum is created as long as the zone elevation does not exceed the elevation the integrated check valve is able to hold back. Consult the manufacturer's literature to understand the maximum feet of elevation permitted with the specific check valve equipped dripline.
   - **I**f vacuum relief valves are needed it is necessary that each zone have its own, as the benefits of a vacuum relief valve are confined to the zone it is installed in.
   - **V**acuum relief valves should always be installed at the highest point(s) in the zone to ensure proper operation.

7. Indicator head
   - Subsurface drip irrigation should always be installed with an indicator head. These are small spray heads that have been modified so they do not discharge any water, but simply pop up during operation to indicate if the zone is operating correctly. If a zone has a break or the valve is not activating, the indicator head will provide evidence of these issues so they may be addressed.

8. Test zones before burial to check for breaks and distribution uniformity.
   - After installation of subsurface drip zone has been completed, but before it is buried, the zone should be activated and allowed to run for several minutes. Seeing the zone run prior to being buried will allow the contractor to visually identify how evenly the dripline distributes water. If an uneven wetting pattern is present, address the lack of uniformity before the zone is buried. If any breaks are discovered at this point in the process, they will be much easier to address than after burial.

Secondary considerations (maintenance & operations)

1. Fertilizer applications
   - If the turfgrass will need to be maintained at a high level of quality because it is a focal point, a sports field, or other area of high importance then additional consideration will need to be given to how the turfgrass will be managed.
   - One way to appropriately provide supplemental nutrients to turfgrass with subsurface drip irrigation is to install a nutrient injector on the irrigation system or in specific zones. These devices directly distribute very small amounts of fertilizer into the dripline as the system is running. This means that the fertilizer is delivered directly to the plant's root zone, where it will be easily absorbed.
2. Periodic inspections/checks
   - Breaks in subsurface drip irrigation can be more difficult to detect because the components are located underground. Therefore, it is necessary to conduct regular checks to avoid wasting water from an irrigation break.

- When checking these irrigation zones, allow them to run for several minutes while visually inspecting the area. Subsurface drip will make a noticeable hissing noise as the dripline pressures up. After the zone has been pressurized it will become silent. If the hissing sound continues or the sound of rushing water becomes noticeable, the zone may have a break and require additional attention.

3. Establishment phase
   - Because subsurface drip is installed at the *established* root zone depth, it is not able to provide adequate amounts of water to seeded or sodded areas located above the established root zone depth. To ensure that a landscape can establish itself it may be necessary to provide overhead irrigation to these areas for the establishment phase.
4. Larger plant material located within the zone
   - Large plant materials such as trees and shrubs may have very different water needs than other plant materials. The Manual requires that irrigation for trees be connected to an independent zone valve that does not irrigate other plant materials. As such, it is not permitted to include tree irrigation in a subsurface drip zone that is meant to irrigate lawn areas.

Parts of a subsurface drip zone or system:

The parts below are commonly used in the construction of a subsurface drip zone or system. While this list covers most of what is common or necessary, it is not comprehensive, and individual projects will vary depending on a number of project-specific conditions.

Valve: Valves are the on/off control for a single zone. When selecting a valve for use in a subsurface drip zone ensure that the zone's low flow rating is below the expected flow rate for the zone it will be used on.

Filter: Due to the smaller orifices used for delivering water to plant material, drip irrigation is more susceptible to clogging than common overhead irrigation. To avoid emitters becoming clogged and non-operational, all drip irrigation should be protected by a filter designed for use with drip irrigation. This can be accomplished by placing a filter on the system's mainline, close to the point of connection, or by installing individual filters on the downstream side of each zone valve. Filters should always be installed in a manner that ensures they will be serviceable in the future. Most drip zone filters are designed to be installed downstream of the zone valve. If a filter is installed upstream of the valve and is under constant pressurization, confirm that the filter is designed for this purpose.

Pressure regulator: Drip irrigation requires lower pressure to operate than overhead spray irrigation. This is due to the emitters, which are smaller and more susceptible to damage from high pressure. To avoid damaging emitters, always install drip irrigation zones with a form of pressure regulation. Many irrigation manufacturers produce assemblies that include a valve meant for use on a drip irrigation zone, a filter, and a pressure regulator in a single unit.

Supply Header: The pipe that runs from the zone valve to the upstream side of the dripline is the supply header. This is the pipe that supplies water from the valve to the dripline during operation.

Exhaust Header: The pipe that connects the downstream sides of the dripline together. It is recommended that both the Supply and Exhaust headers be installed 3-4" below the dripline in order to collect any grit in the headers where it can be more easily flushed out of the zone (see Flush Valves).

Dripline: The product type used for subsurface drip irrigation is called dripline. Dripline is the .5" pipe used for typical drip irrigation applications, but it has been manufactured with integrated inline drip emitters at regular intervals. Sub-surface dripline includes root intrusion protection mechanisms within the integrated drip emitters to prevent clogging from root growth. It is important to select a dripline designed specifically for sub-surface applications.

Flush valve: The emitters integrated into the dripline product are susceptible to clogging due to the small size of the discharge orifice. To reduce the frequency in which the emitters clog, subsurface drip zones should be installed with a dedicated flush valve. These should be installed at the point in the zone that is the furthest from the zone valve. These flush valves should be installed in such a way that they are easy to access, so they can be used to flush the system on a regular basis. If possible, install the flush valve(s) in the exhaust header at a point furthest from the water supply point. Some zones may require more than one flush valve. Try to install a flush valve at the lowest elevation points in the zone where grit may accumulate.

Vacuum relief valve: Subsurface drip irrigation is vulnerable to internal vacuum forces that can occur after a zone completes running. To avoid damaging emitters or pipes due to vacuum forces, a vacuum relief valve should be installed at the highest point on each zone. These valves allow air to enter the pipe when there is negative pressure present. This will ensure that soil particles are not drawn into emitters and that the pipes are not crushed from the internal vacuum force. Dripline with integrated check valves do not require vacuum relief valves.

Appendix A: Dripline calculators:

https://www.rainbird.com/calculator

https://www.hunterindustries.com/tools/hunter-dripline-calculator

https://techline.netafimusa.com/calculator/calculate

http://irrigation.wsu.edu/Content/Calculators/Drip/Drip-Line-Rate.php

https://specifier.toro.com/torodriplinecalc.htm

Appendix B: Self done soil test links:

Jar:https://extension.unl.edu/statewide/lincolnmcpherson/Soil%20Texture%20Analysis%20%E2%80%9CThe%20Jar%20Test%E2%80%9D.pdf

Ribbon: https://files.dnr.state.mn.us/forestry/ecssilviculture/forms_worksheet/soil-texture-key.pdf