CRITERIA FOR SUCCESSFUL ADOPTION OF SDI SYSTEMS

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INTRODUCTION

Subsurface drip irrigation (SDI) systems are currently being used on about 15,000 acres in Kansas. Research studies at the NW Kansas Research and Extension Center of Kansas State University begin in 1989 and have indicated that SDI can be adapted for efficient, long-term irrigated corn production in western Kansas. This adaptability has been demonstrated on other deep-rooted irrigated crops grown in the region by demonstration plots and producer experience. Many producers have had successful experiences with SDI systems; however most experienced at least some minor technical difficulties during the adoption process. However, a few systems have been abandoned or failed after a short use period due to problems associated with inadequate design, inadequate management, or a combination of both.

Both research studies and on-farm producers experience indicate SDI systems can result in high yielding crop and water-conserving production practices, but only if the systems are properly designed, installed, operated and maintained. SDI systems in the High Plains must also have long life to be economically viable when used to produce the relatively low value field crops common to the region. Design and management are closely linked in a successful SDI system. A system that is not properly designed and installed will be difficult to operate and maintain and most likely will not achieve high irrigation water application uniformity and efficiency goals. However, proper design and installation does not ensure high SDI efficiency and long system life. An SDI system must be operated at design specifications and utilize good irrigation water management procedures to achieve high uniformity and efficiency. An SDI is also destined for early failure without proper maintenance. This paper will review important criteria for successful adoption of SDI for Kansas irrigated agriculture.

MINIMUM SDI SYSTEM COMPONENTS FOR WATER DISTRIBUTION AND EFFICIENT SYSTEM OPERATION

Design considerations must account for field and soil characteristics, water quality, well capabilities, desired crops, production systems, and producer goals. It is difficult to separate design and management considerations into distinct issues as the system design should consider management restraints and goals. However, there are certain basic features that should be a part of all SDI systems, as shown in Figure 1. Omission of any of these minimum components by a designer should raise a red flag to the producer and will likely seriously undermine the ability of the producer to operate and maintain the system in an efficient manner for a long period of time. Minimum SDI system components should not be sacrificed as a design and installation cost cutting measure. If minimum SDI components cannot be included as part of the system, serious consideration should be given to an alternative type of irrigation system or remaining as a dryland production system.

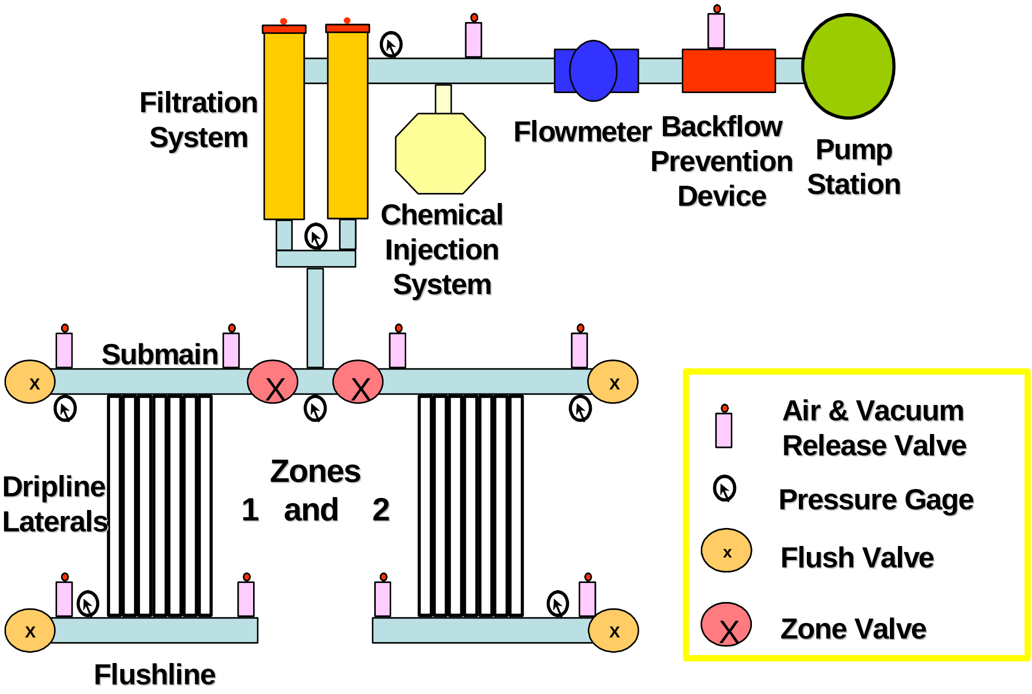


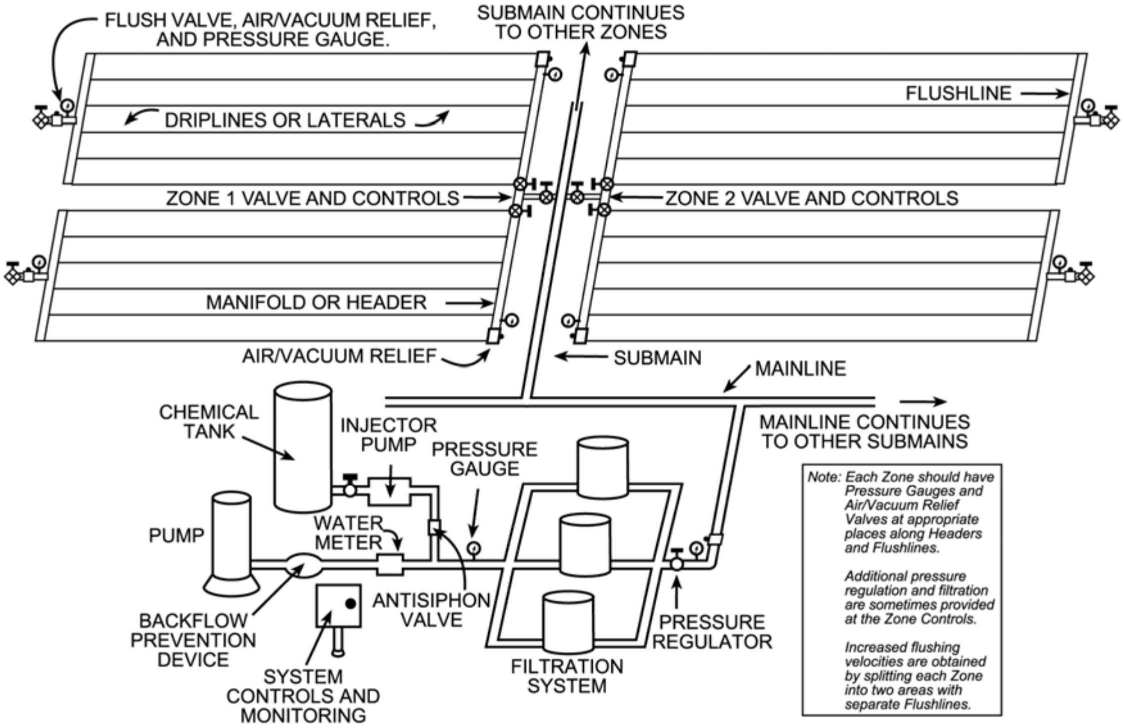
Figure 1. Minimum components of an SDI system. (Components are not to scale) K-State Research and Extension Bulletin MF-2576, Subsurface Drip Irrigation (SDI) Component: Minimum Requirements.

The water distribution components of an SDI system are the pumping station, the main, submains and dripline laterals. The size requirements for the mains and submains would be similar to the needs for underground service pipe to center pivots or main pipelines for surface flood systems. Size is determined by the flow rate and acceptable friction loss within the pipe. In general, the flow rate and acceptable friction loss determines the dripline size (diameter) for a given dripline lateral length. Another factor is the land slope. An SDI system consisting of only the distribution components would have no method to monitor system performance and the system would not have any protection from clogging or any methods to conduct system maintenance. Clogging of dripline emitters is the primary reason for SDI system failure.

The actual characteristics and field layout of an SDI system will vary from site to site, but often irrigators will want to add additional capabilities to their system. For example, the SDI system in Figure 2 shows additional valves that allow the irrigation zone to be split into two flushing zones. The ability to flush SDI systems is essential. Filter systems are generally sized to remove particles that are approximately 1/10 the diameter of the smallest emitter passageway. However, this still means small particles pass through the filter and into the driplines. Overtime, they can clump together and/or other biological or chemical processes can produce materials that need removal to prevent emitter clogging. The opening of the flushline valves and allowing water to pass rapidly through carrying away any accumulated particles flushes the driplines. A good design should allow flushing of all pipeline and system components. If the well or pump does not have the capacity to provide additional flow and pressure to meet the flushing requirements for the irrigation zone, splitting of the zone into two parts may be an important design feature. The frequency of flushing is largely determined by the quality of the irrigation water and to a degree, the level of filtration. A good measure of the need to flush is to evaluate the amount of debris caught in a mesh cloth during a flush event. If little debris is found, the flushing interval might be increased but heavy accumulations might mean more frequent flushing is needed.

The remaining components, in addition to the water distribution components of Figure 1, are primarily components that allow the producers to monitor the SDI system performance, to protect or maintain performance by injection of chemical treatments, and to allow flushing. The injection equipment can also be used to provide additional nutrients or chemicals for crop production. The backflow preventive device is a requirement to protect the source water from accidental contamination should a backflow condition occur.

The flow meter and pressure gauges are essentially the operational feedback cues to the manager. In SDI systems, all water application is underground. In most properly installed and operated systems, no surface wetting occurs during irrigation, so no visual cues are available to the manager concerning the system operating characteristics. The pressure gauges at the control valve of each zone allow the measurement of the inlet pressure to driplines. Decreasing flow and/or increasing pressure can indicate clogging is occurring. Increasing flow with decreasing pressure can indicate a major line leak. The pressure gauges at the distal ends of the dripline laterals are especially important in establishing the baseline performance characteristics of the SDI system. Flowrate and pressure measurement records can be used as a diagnostic tool to discover operational problems and determine appropriate remediation techniques (Figure 3).



Note: Each Zone should have Pressure Gauges and Air/Vacuum Relief Valves at appropriate places along Headers and Flushlines.

Additional pressure regulation and filtration are sometimes provided at the Zone Controls.

Increased flushing velocities are obtained by splitting each Zone into two areas with separate Flushlines.

Figure 2. An example layout for a well designed SDI system.

Anomaly A: The irrigator observes an abrupt flowrate increase with a small pressure reduction at the Zone inlet and a large pressure reduction at the Flushline outlet. The irrigator checks and finds rodent damage and repairs the dripline.

Anomaly B: The irrigator observes an abrupt flowrate reduction with small pressure increases at both the Zone inlet and the Flushline outlet. The irrigator checks and finds an abrupt bacterial flare-up in the driplines. He immediately chlorinates and acidifies the system to remediate the problem.

Anomaly C: The irrigator observes an abrupt flowrate decrease from the last irrigation event with large pressure reductions at both the Zone inlet and Flushline outlet. A quick inspection reveals a large filtration system pressure drop indicating the need for cleaning. Normal flowrate and pressures resume after cleaning the filter.

Anomaly D: The irrigator observes a gradual flowrate decrease during the last four irrigation events with pressure increases at both the Zone inlet and Flushline outlet. The irrigator checks and find that the driplines are slowly clogging. He immediately chemically treats the system to remediate the problem.

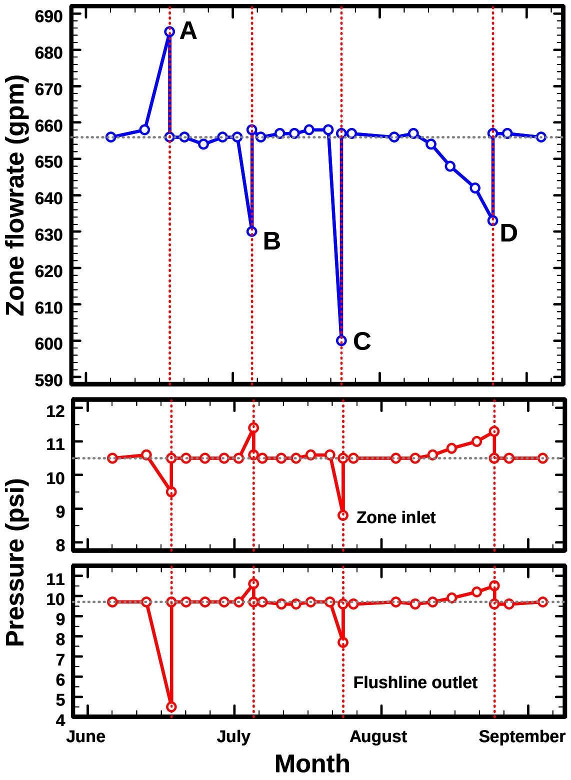


Figure 3. Hypothetical example of how pressure and flowrate measurement records could be used to discover and remediate operational problems.

The heart of the protection system for the driplines is the filtration system. The type of filtration system needed will depend on the quality characteristics of the irrigation water. Clogging hazards are classified as physical, biological or chemical. The illustration in Figure 1 depicts a pair of screen filters, while Figure 2 shows a series of sand media filters. In some cases, the filtration system may be a combination of components. For example, a well that produces a lot of sand in the pumped water may require a cyclonic sand separator in advance of the main filter. Sand particles in the water would represent a physical clogging hazard. Another common type of filtration system is the disc filter.

Biological hazards are living organisms or life by-products that can clog emitters. Surface water supplies may require settling basins and/or several layers of bar screen barriers at the intake site to remove large debris and organic matter. Sand media filtration systems, which consist of a bank of two or more large tanks with specially graded filtration sand, are considered to be well suited for surface water sources. Water sources that have a high iron content, can also be vulnerable to biological clogging hazards, such as when iron bacteria flare-up in a well. Control of bacterial growths generally requires water treatment in addition to filtration.

Chemical clogging hazards are associated with the chemical composition or quality of the irrigation water. As water is pulled from a well and introduced to the distribution system, chemical reactions can occur due to changes in temperature, pressure, air exposure, or also by the introduction of other materials into the water stream. If precipitants form, they can clog the emitters.

The chemical injection system is often considered to be a part of the filtration system but it can also be used to inject nutrients or chemicals to enhance plant growth or yield. There are a variety of types of injectors that can be used; the choice of unit depends on the desired accuracy of injection of a material, the rate of injection, and the agrochemical being injected. There are also state and federal laws that govern the type of injectors, required safety equipment (Figure 4), appropriate agrochemicals and application amounts that can be used in SDI systems. Always follow all applicable laws and labels when applying agrochemicals. Many different agrochemicals can be injected, including chlorine, acid, dripline cleaners, fertilizers, and some pesticides. Producers should never inject any agrochemical into their SDI system without knowledge of the agrochemical compatibility with the irrigation water. For example, many phosphorus fertilizers are incompatible with many water sources and can only be injected using additional precautions and management techniques. If a wide variety of chemicals are likely to be injected, then the system may require more than one type of injection system. The injection systems in Figures 1 and 2 are depicted as a single injection point, located upstream of the main filter. Some agrochemicals might require an injection point downstream from the filter location to prevent damage to the filter system. However, this should only be done by experienced irrigators or with an expert consultant, since the injection bypasses the protection of the filter system.

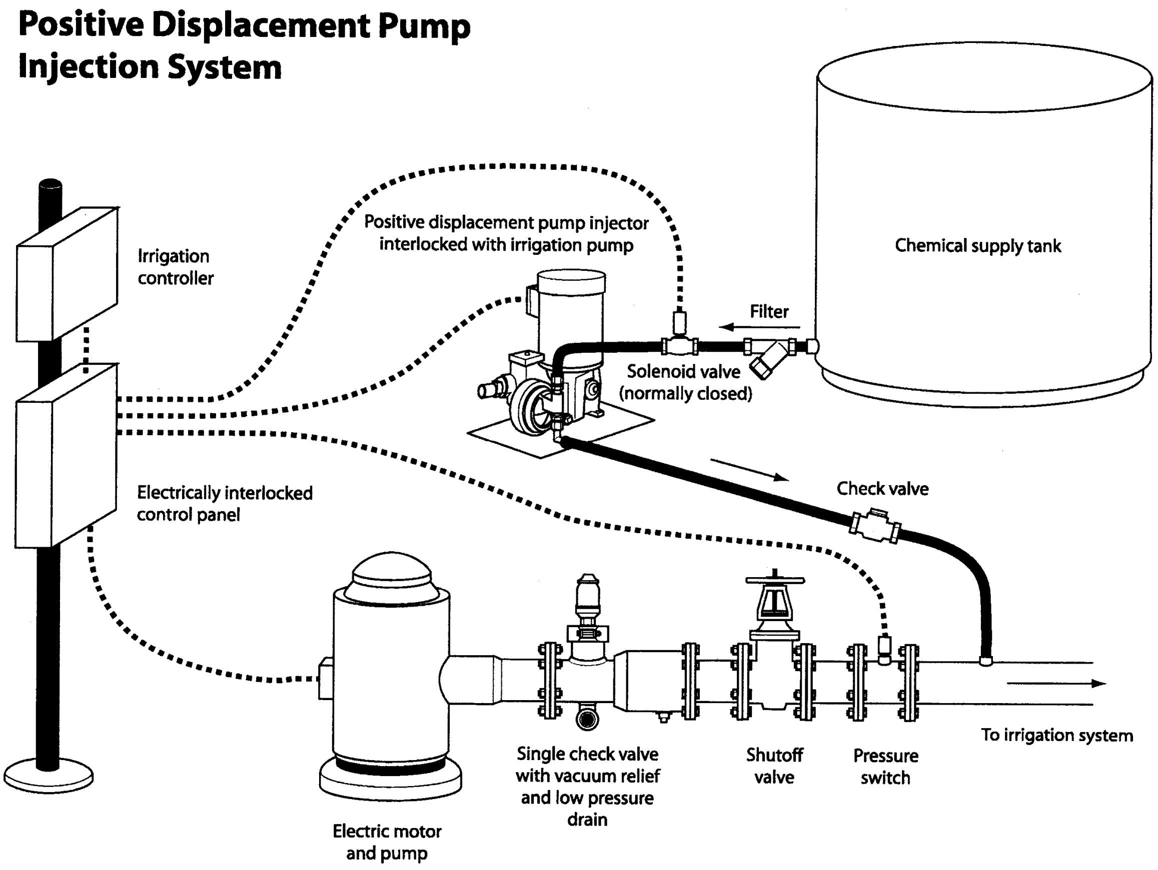


Figure 4. Typical layout for an injection system showing many of the safety interlocks and backflow prevention devices required to prevent contamination of the environment. (Courtesy of L.J. Schwankl, Univ. of California-Davis).

Chlorine is commonly injected to disinfect the system and to minimize the risk of clogging associated with biological organisms. Acid injection can also lower the pH chemical characteristic of the irrigation water. For example, high pH water may have a high clogging hazard due to a mineral dropping out of solution in the dripline after the filter. The addition of a small amount of acid to lower the pH to slightly acidify the water might prevent this hazard from occurring.

Water quality can have a significant effect on SDI system performance and longevity. In some instances, poor water quality, such as high salinity, could cause soil quality and crop growth problems. However, with proper treatment and management, water with high mineral loading, water with nutrient enrichment or water with high salinity can be used successfully in SDI systems. However, no system should be designed and installed without first assessing the quality of the proposed irrigation water supply.

WATER QUALITY ANALYSIS RECOMMENDATIONS

Prevention of clogging is the key to SDI system longevity and prevention requires understanding of the potential problems associated with a particular water source. Information on water quality should be obtained (Table 1) and made available to the designer and irrigation manager in the early stages of the planning process so that suitable system components, especially the filtration system, and management and maintenance plans can be selected.

Table 1. Recommended water quality tests

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1. Electrical Conductivity (EC) - measured in ds/m or mmho/cm - a
   measure of total salinity or total dissolved solids;

2. pH - a measure of acidity -
   where 1 is very acid, 14 is very alkali, and 7 is neutral;

3. Cations - measured in meq/L, (milliequivalent/liter), includes;
   Calcium (Ca),
   Magnesium (Mg), and
   Sodium (Na);

4. Anions - measured in meq/L, includes:
   Chloride (Cl),
   Sulfate (SO_4),
   Carbonate (CO_3), and
   Bicarbonate (HCO_3);

5. Sodium Absorption Ratio (SAR) - a measure of the potential for sodium in the water to develop sodium sodicity, deterioration in soil permeability and toxicity to crops. SAR is sometimes reported as Adjusted (Adj) SAR. The Adj. SAR value better accounts for the effect on the HCO_3 concentration and salinity in the water and the subsequent potential damage by sodium to the soil.

6. Nitrate nitrogen (NO_3 - N) - measured in mg/L(milligram/liter);

7. Iron (Fe),
   Manganese (Mn), and
   Hydrogen Sulfide (H_2S) - measured in mg/L;

8. Total suspended solids - a measure of particles in suspension - in mg/L;

9 Bacterial population - a measure or count of bacterial presence in # / ml, (number per milliliter);

10. Boron* - measured in mg/L;

11. Presence of oil**

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* The boron test would be for crop toxicity concern.

** Oil in water would be concern for excessive filter clogging. It may not be a test option at some labs, and could be considered an optional analysis.

Results for Tests 1 through 7 are likely to be provided in a standard irrigation water quality test package. Tests 8 through 11 are generally offered by water labs as individual tests. The test for presence of oil may be a test to consider in oil producing areas of the state or if the well to be used for SDI has experienced surging, which may have mixed existing drip oil in the water column into the pumped water. The fee schedule for Tests 1 through 11 will vary from lab to lab and the total cost for all recommended tests may be a few hundred dollars. This is still a minor investment in comparison to the value offered by the test in helping to determine proper design and operation of the SDI system.

PRODUCER RESPONSIBILITIES

As with most investments, the decision lies with the investor. Good judgments generally require a good understanding of the fundamentals of the particular opportunity and/or the recommendations from a trusted and proven expert. While the microirrigation (drip) industry dates back over 40 years now and its application in Kansas as SDI has been researched since 1989, a network of industry support is still in the early development phase in the High Plains region. Individuals considering SDI should spend time to determine if SDI is a viable systems option for their situation. They might ask themselves:

What things should I consider before I purchase a SDI system?

1. Educate yourself before contacting a service provider or salesperson by
    a. Seeking out university and other educational resources. Good places to start are the K-State SDI website at http://www.oznet.ksu.edu/sdi/ and the Microirrigation forum at http://www.microirrigationforum.com/. Read the literature or websites of companies as well.
    b. Reviewing minimum recommended design components as recommended by K-State. http://www.oznet.ksu.edu/sdi/Reports/2003/mf2576.pdf
    c. Visit other producer sites that have installed and used SDI. Most current producers are willing to show them to others.
2. Interview at least two companies.
    a. Ask them for references, credentials (training and experience) and sites (including the names of contacts or references) of other completed systems.
    b. Ask questions about design and operation details. Pay particular attention if the minimum SDI system components are not met. If not, ask why? System longevity is a critical factor for economical use of SDI.
    c. Ask companies to clearly define their role and responsibility in designing, installing and servicing the system. Determine what guarantees are provided.
3. Obtain an independent review of the design by an individual that is not associated with sales. This adds cost but should be minor compared to the total cost of a large SDI system.

SUMMARY AND CONCLUSIONS

Subsurface drip irrigation offers a number of agronomic production and water conservation advantages but these advantages can only be achieved with proper design, operation, and maintenance, so that the SDI system can have an efficient, effective, and long life. One management change from current irrigation systems is the need to understand the SDI system sensitivity to clogging by physical, biological and/or chemical agents.

Before designing or installing an SDI system, be certain a comprehensive water quality test is conducted on the source water supply. Once this assessment is complete, the system designer can alert the manager of any potential problems that might be caused by the water supply. The old adage "an ounce of prevention is worth a pound of cure" is very appropriate for SDI systems. Early recognition of developing problems and appropriate action can prevent larger problems. While this may seem daunting at first, as with most new technology, most managers quickly will become familiar with the system and its operational needs.

The SDI operator/manager also needs to understand the function and need for the various components of an SDI system. There are many accessory options available for SDI systems that can be included during the initial design and installation phases, and even added at a later time, but more importantly, there are minimum design and equipment features that must be included in the basic system. SDI can be a viable irrigation system option, but should be carefully considered by producers before any financial investment is made.

The SDI operator/manager should monitor and record zone flowrates and pressures during ever irrigation event so that through observation of short and long term performance trends, operational problems can be discovered and remediated immediately.

OTHER AVAILABLE INFORMATION

The above discussion is a very brief summary from materials available through K-State. The SDI related bulletins and irrigation-related websites are listed below:

MF-2361	*Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems* *http://www.oznet.ksu.edu/sdi/Reports/2003/mf2361.pdf*
MF-2576	*Subsurface Drip Irrigation (SDI) Components: Minimum Requirements* *http://www.oznet.ksu.edu/sdi/Reports/2003/mf2576.pdf*
MF-2578	*Design Considerations for Subsurface Drip Irrigation* *http://www.oznet.ksu.edu/sdi/Reports/2003/mf2578.pdf*

MF-2590 *Management Consideration for Operating a Subsurface Drip Irrigation System* http://www.oznet.ksu.edu/sdi/Reports/2003/MF2590.pdf

MF-2575 *Water Quality Assessment Guidelines for Subsurface Drip Irrigation* http://www.oznet.ksu.edu/sdi/Reports/2003/mf2575.pdf

MF 2589 *Shock Chlorination Treatment for Irrigation Wells* http://www.oznet.ksu.edu/sdi/Reports/2003/mf2589.pdf

Related K-State Research and Extension Irrigation Websites:

Subsurface Drip Irrigation http://www.oznet.ksu.edu/sdi/

General Irrigation http://www.oznet.ksu.edu/irrigate/

Mobile Irrigation Lab http://www.oznet.ksu.edu/mil/

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