Prairie Provinces

Trickle Irrigation Manual

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PRAIRIE PROVINCES TRICKLE IRRIGATION MANUAL

INTRODUCTION

WHAT IS TRICKLE IRRIGATION?

Trickle Irrigation, often called Drip Irrigation, falls under the broader heading of Micro-irrigation. Micro-irrigation is the accepted term used to describe the frequent and low application of water by small devices, commonly called emitters. Emitters are devices used to regulate the flow of water to the plants. Generally, anything smaller than a lawn sprinkler will fall under the category of Micro-irrigation. The idea of trickle irrigation is to provide optimum growing conditions by applying water and nutrients directly to the plant. Quantities of applied water should approach the consumptive use of the plant, while maintaining a proper air-water balance in the soil for healthy root development.

A Trickle irrigation system is made up of various components: A pump or pressurized water source, filtration unit, main line, header line, valves, fittings and lateral lines where the emitter devices are located (Figure 1). Additional equipment often used with trickle irrigation systems are pressure controllers, backflow prevention devices, chemical injectors for water treatment, fertilizer injectors, automatic timers, soil moisture monitoring devices and system failure alarms.

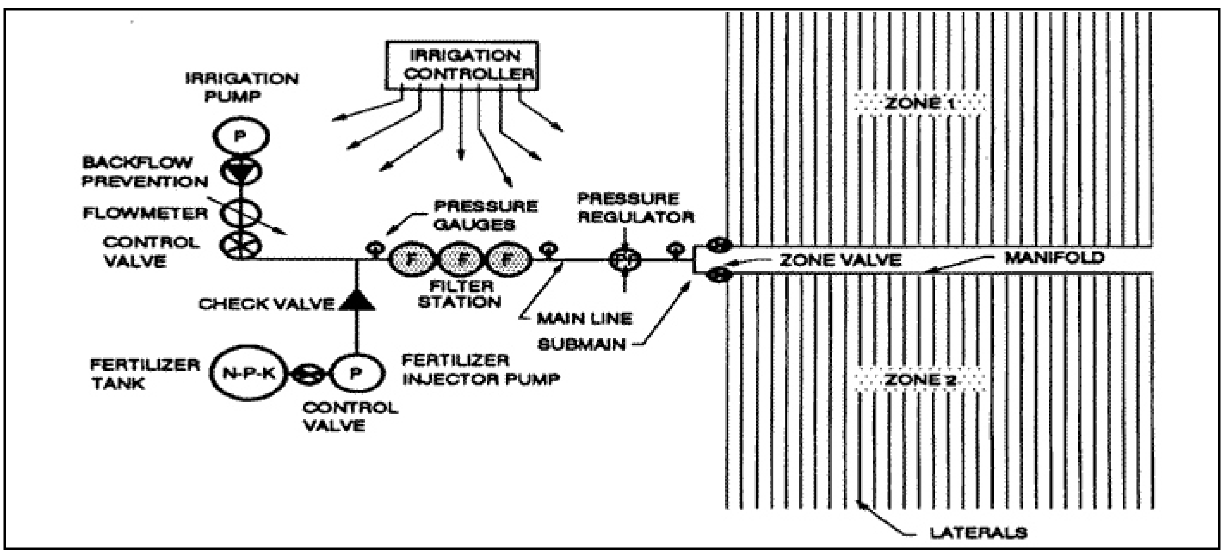

Figure 1: Typical layout and various components of a Trickle Irrigation system

ADVANTAGES OF TRICKLE IRRIGATION

- **Lower volumes of water are used** - crops can be grown with a limited water supply.
- **Better use of available water** - this is especially important as competition for water resources between users becomes greater.
- **Energy savings** - lower water volumes are pumped at low pressure reducing energy needs.
- **Reduced weed growth** - only the targeted root zone or plants are watered.
- **Optimum plant growth** - water and fertilizer target the plant, reducing plant stress and creating ideal growing conditions without competition from weeds and other plants.
- **Reduced chemical and labour costs** - watering of plant rows only means poor growing conditions for weeds between rows. Also, mulching and garden cloth work well in trickle systems.
- **No significant runoff** means **less soil erosion**.
- **Soil temperature, air and water content stay relatively constant** - the slow application of water to the plant over an extended period of time is less of a shock to plants than other methods of irrigation.
- **Reduced disease** - diseases of foliage commonly spread by water are reduced since only the root zone is watered.
- **Automation** - trickle systems are readily automated.
- **Aeration -** using air with trickle for aeration of ponds and dugouts to keep water open for winter construction or livestock watering is a potential use micro-irrigation systems.

DISADVANTAGES OF TRICKLE IRRIGATION

- **Plugging** - since the devices used in trickle irrigation are small, plugging can occur from algae, soil, foreign particles and hard water deposits. These problems are mostly avoided with proper filters and water treatment.
- **High management requirement** - only part of the root zone of the plant is watered, therefore soil moisture must be monitored to a greater degree to avoid plant stress.
- **Cost** - the initial investment may be greater depending on the type of system required for particular crops, the equipment needed for water treatment, and the degree of automation.
- **Control of the microenvironment -** with only the roots being watered, misting of plants with water for cooling or frost protection is not possible. A dual system with both sprays and point source emitters can alleviate this problem, but the cost may be prohibitive.

SYSTEM COMPONENTS

WATER SOURCE

The water source for trickle irrigation can be a well, rural pipeline, dugout, irrigation canal, reservoir, river, lake, cistern (holding tank), or municipal water connection. The quantity and quality of the water source should be determined for initial design considerations. All water sources require government licensing for irrigation. Generally, the local offices of **Saskatchewan Agriculture and Food**, **Sask Water** or **PFRA** will assist in evaluating and licensing the irrigation project. See Appendix 2 for a list of federal and provincial agencies specializing in irrigation.

POWER SOURCE

Electric power is preferred for trickle irrigation systems because of low maintenance and quiet pump operation. Electric power can be either single-phase (120-240v) (240-480v) or three-phase (480v). Most common is single-phase power that can handle a 7-horsepower motor. If three-phase is not readily available, it is often not economical to have it installed due to high capital cost (up to $22,000/km). A recent innovation in electric motors are variable speed motors that start up at a low speed and gradually increase in speed and horsepower. This avoids the sudden large power demand that occurs when a conventual motor starts and allows higher horsepower motors to be used on a light power line.

If electric power is not available, or a large horsepower pump is necessary, alternative power sources such as natural gas, propane, diesel or gasoline can be used.

PUMPS

The type of pump selected for the trickle irrigation system depends on the water source, degree of lift (suction of water), and pressure and volume of water required. Centrifugal and turbine pumps are the most common types used in trickle systems. The motors of these pumps can be submersible, or non-submersible.

Centrifugal Pumps are most commonly used when pumping water from shallow lakes, rivers, reservoirs, canals, very shallow wells, dugouts and cisterns (holding tanks). Generally, pumping ability and efficiency are greatly reduced if suction lift is over 20 ft.

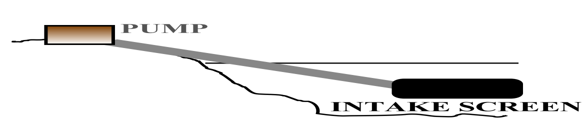

Figure 2: Pump Intake Screen

Submersible and Turbine Pumps are commonly used in wells or high lift situations. Submersibles are often used in small wells.

Pump Intakes often need a screen installed on the pump suction line to prevent large debris from entering the pump. The screen should be located at least two feet below water surface, but held up from the bottom of the water source (Figure 2).

BACK FLOW PREVENTORS, CHECK VALVES AND VACUUM BREAKERS

Back flow preventors and **check valves** are safety devices installed downstream of the pump or pressurized water supply. In cases of low pressure, contaminated water from the irrigation system can flow back into the water source or dirty water can be sucked back into lateral lines, plugging the emitters. Often considered optional equipment with trickle irrigation systems, they are standard equipment on public water supplies. They are necessary if chemicals or fertilizers are being injected into the system.

Vacuum breakers or **air release valves** are another type of safety device which allow air into the header lines when the system is shut down. This prevents soil particles from being drawn back into the emitters. They are required for underground installation of dripper lines and are recommended for all trickle irrigation systems.

CHEMICAL INJECTORS

Chemical injectors are installed after the backflow preventor. They often use two independent injection ports: One before the filter for non-corrosive chemicals, and one after the filter for chemicals which are corrosive to the filter and do not need filtering. Chemicals for water treatment (chlorine or acids), fertilizers, herbicides, nematicides, or insecticides are injected into the system as a concentrated liquid which is then diluted with irrigation water.

Venturi Injectors do not require a power source, are inexpensive and require little maintenance since there are no moving parts. These injectors use pressurized water diverted from the irrigation system to create a pressure drop. In order to insure a large enough pressure drop, the injector should be installed on either side of a flow restrictor such as a valve. The mechanics of the venturi are very simple (Figure 3): Water flows through the injector, increases speed at a constriction thus creating a suction that draws chemical through a small hole located in the constricted portion of the injection device.

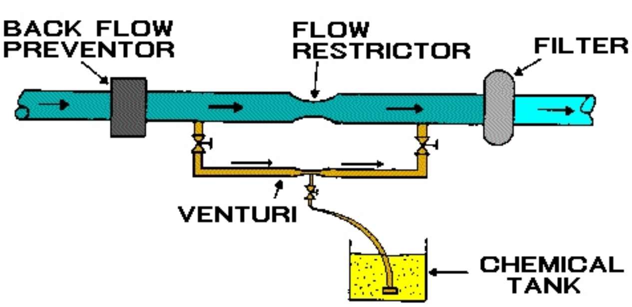

Figure 3: Typical layout of aVenturi Injector

Injector Pumps are electric or water-driven. They are designed to inject chemicals at a constant rate under pressure into the irrigation system. Metering injector pumps are recommended when it is crucial that a constant level of chemical be injected into the system. These pumps should have safety devices to prevent undiluted chemical from pumping into the system if water stops flowing.

FILTERS

Water quality can be greatly affected by physical, chemical and biological contaminants that may cause emitter plugging. Therefore, a properly designed, reliable filter is the most important component in the irrigation system. There are several types of filters used alone or in combination with one another for effective filtration of contaminants. Selection of a filter depends on the size of the emitter's opening (emitter manufacturers have specific filter size recommendations), the flow rate of the irrigation system and the amount and type of contaminant to be filtered from the water source. Filters should be sized to remove particles 1/10 the diameter of the smallest opening in the emitter flow path.

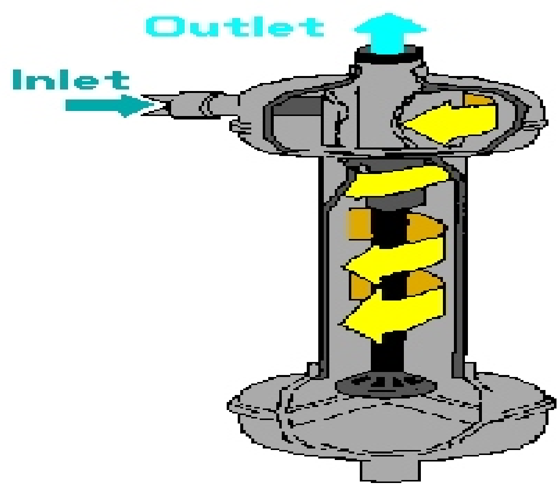

Figure 4: Cyclone Filter

Cyclone Filters or **Centrifugal Separators** are used as a primary filter in cases of very dirty water or high sand load, followed by one of the filters described below for secondary filtering. Cyclone filters use centrifugal force to remove contaminants (Figure 4). Water enters the filter in a spinning motion which sends contaminants to the wall of the filter. These contaminants (mostly physical) settle to the bottom of the filter in a collection chamber, while clean water is drawn from the center. The collection chamber may have a manual or an automatic flush valve at the bottom to clean the filter. Cyclone filters need a constant flow of water for efficient operation.

Media Filters are commonly used for trickle irrigation systems because of their versatility and ability to trap large amounts of physical and biological contaminants in the filter bed. The filter media consists of a thin layer of coarse gravel and a thick layer of sand placed in pressurized tanks (Figure 5). The finer the sand, the smaller the particle removed by the filter.

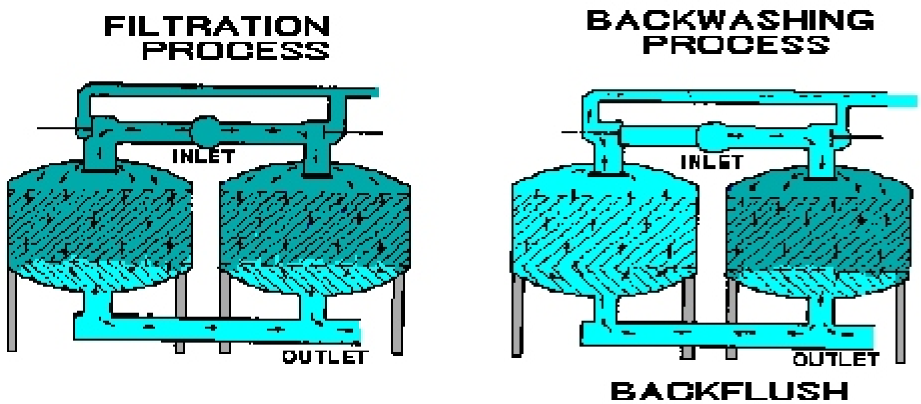

Figure 5: Media Filters showing filtration and backflush process

Various sand sizes and shapes can be compared to screen mesh equivalents (Table 1). The size of media filter required is determined by the flow rate of the system and is measured by the surface area of the filter. Manufacturers provide recommendations, but in general, for every 20 gpm (gallons per minute) of flow there should be a minimum of one square foot of top surface area.

Media filters are cleaned by reversing the flow of water. This can be done manually or automatically by timers or pressure drop across the filter. Proper backwashing is necessary to avoid compaction and to clean the sand of contaminants. A screen filter of 200 mesh should be installed after the sand filter in case sand gets into the system during backwashing. At least two filters are required to allow for backwashing with filtered water.

Table 1: Equivalent screen mesh size to media size and type

MEDIA	SCREEN MESH SIZE
#8 CRUSHED GRANITE	100-140
#11 CRUSHED GRANITE	140-200
#12 CRUSHED SILICA	130-140
#16 CRUSHED SILICA	150-200
#20 CRUSHED SILICA	200-250

Disc filters are commonly used in place of screen filters if the water source is borderline with organic contaminants. They consist of lightweight, compact stacks of grooved, washer-like discs (Figure 6) that provide more filter surface area than screen filters of the same size. The discs are compressed in a moulded plastic or stainless steel filter body by a screw-on cap and water pressure when the irrigation system is operating.

The discs of the filters are stacked in opposing directions creating an interface of X's. Water flows from the outside through the discs. Debris is caught and held on and between the discs, while the clean water is dispersed from the centre. Discs are rated as mesh equivalents to screen filter sizes (see manufacturers' specifications). To backflush, run clean water backwards throughout the discs. Some disc filters have an automatic backwash feature.

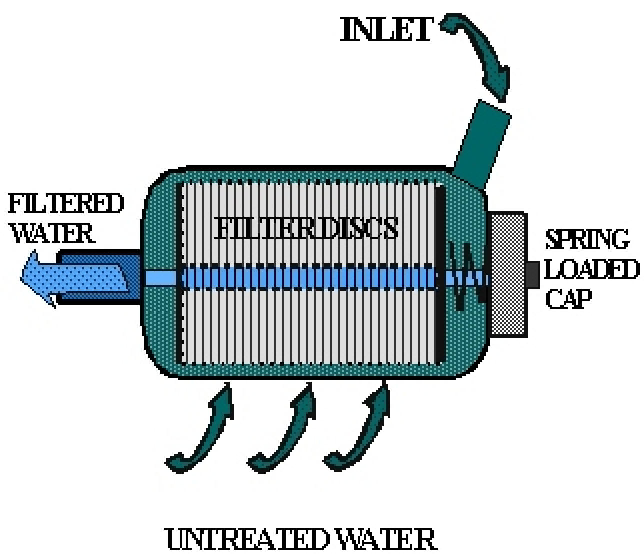

Figure 6: Disc Filter

Screen filters are simple and inexpensive but only remove small amounts of physical and biological contaminants. These filters are commonly used in combination with other filters as backup filters. They can be used alone when the water source is very clean and free from algae (which can squeeze through the screen and cause plugging). They come in a variety of shapes and sizes from in-line to y-shape (Figure 7). The filtering screen is made of plastic or steel mesh. The mesh size is determined by the number of openings per linear inch (the more openings, the finer the filter). Most trickle systems require filters of 140 mesh or finer. Some screen filters are designed with a valve on the bottom which can be opened to clean the filter or can be partially left open to clean continuously while the system is operating. Self-cleaning screen filters with various innovations such as internal brushes which clean the filter screen are available.

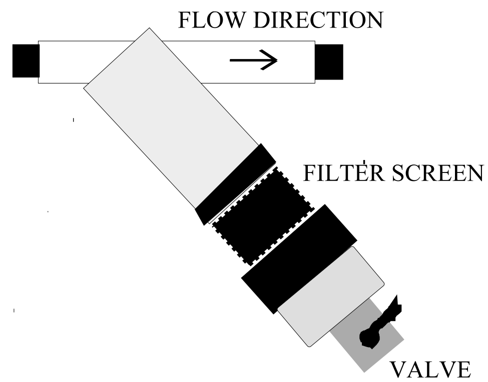

Figure 7: Screen Filter

MONITORING AND CONTROL EQUIPMENT

Valves are used in trickle systems to control and direct the flow of water. They include gate valves, ball valves and solenoid valves (for automatic operation).

Pressure Regulators are used to maintain a desired pressure and flow rate for non pressure compensating emitters and for drip tape. There are preset (non-adjustable) and adjustable pressure regulators. Pressure regulators are often used throughout the trickle system (usually at the head of sub-mains) to stabilize pressure due to elevation differences or high water pressure.

Flow Meters are often installed to monitor system flow rate. It is important to keep track of operating flow rates to find problems before they are serious. A reduction in flow may indicate plugging problems while an increase in flow may indicate a line break.

Pressure Gauges are used as a visual aid to monitor pressure throughout the system. Gauges are generally placed at the pump discharge, on each side of the filter to indicate when cleaning is necessary, and in each sub-main throughout the system. Pressure gauges provide a quick reference as to whether the system is operating at the correct pressure. Reduction in pressure indicates plugging of filters, while an increase in pressure may indicate a faulty pressure regulator.

Irrigation Controllers are devices which use timer clocks to automatically turn irrigation equipment off and on at preset times. The type of controller selected depends on the number of devices it must control. Applications which are commonly automated include starting and stopping the pump and chemical injector, backwashing filters, monitoring soil moisture, and sequencing watering times for individual zones in the trickle system.

DISTRIBUTION LINES

Distribution lines for a trickle system include the mainline, sub-mains, manifold and laterals (Figure 8). Plastic pipe is preferred for its high resistance to corrosion, and its good friction loss characteristics (due to the smooth inner surface). Friction loss is the loss of pressure caused friction between water flowing through the system and the pipe walls. The rougher the inside of the pipe, the more turbulent the water flow and, therefore, the higher the pressure loss. Friction loss is determined by the flow, length of pipe, and size and type of pipe. Refer to Appendix 1 for a sample friction loss table (psi loss per 100 ft) for polyethylene pipe.

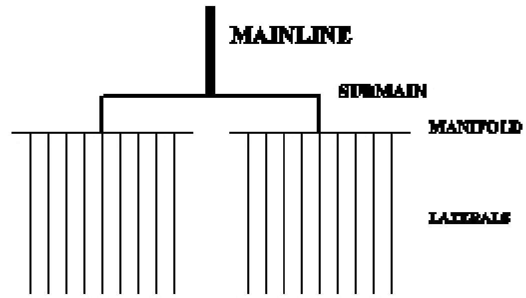

Figure 8: Trickle Distribution line layout

It is important to use the correct friction loss table for the chosen pipe. Use the manufacturers' friction loss data if possible. Flow velocities of more than 5 feet per second should be avoided when selecting the size of pipe used for each portion of the distribution system.

For Example: Select the proper pipe size for 300 ft. manifold of polyethylene tubing with a 40 gpm (gallon per minute) flow and 22 outlets.

Step 1:

☞ Select the appropriate friction loss chart for the polyethylene pipe (use Appendix 1 for this example).

☞ Look on the left-hand column for the 40 gpm flow rate, look across chart and find the velocity fps and psi loss which are just above the bold lettered values (4.42 fps and 1.61 psi loss per 100 ft). Now look to the top of the chart to see which pipe size to select (1½").

☞ For 300 ft of 1½" polyethylene pipe the psi loss would be 1.61 x 3 = 4.83 psi loss

Step 2:

☞ Friction loss decreases each time the water passes an outlet. This must be taken into account for the final friction loss calculation. Refer to Table 2 for Pipe friction loss factor "F" for Multiple outlets.

☞ The actual friction loss for the 1½" polyethylene pipe would be 4.83 psi loss x 0.357 ("F" factor for 22 outlets extrapolated from Table 2).

☞ Therefore, the new corrected friction loss would be 4.83 x 0.357 = 1.72 psi loss

Table 2: Pipe Friction Loss Factor "F" for multiple outlets

# OUTLETs	"F"	# OUTLETS	"F"	# OUTLETS	"F"
1	1.000	9	0.391	22	0.357
2	0.625	10	0.385	24	0.355
3	0.518	11	0.380	26	0.353
4	0.469	12	0.376	28	0.351
5	0.440	14	0.370	30	0.350
6	0.421	16	0.365	40	0.345
7	0.408	18	0.361	50	0.343
8	0.398	20	0.359	100	0.338

Data for Table 2 taken from Hardie Design Manual

PVC pipe is a ridged plastic pipe which joins together by glueing or gasket lock. It is susceptible to damage by the sun's ultraviolet light and should be buried. PVC pipe is often used for mainlines and sub-mains.

Polyethylene pipe can be high density or low density. High density polyethylene pipe is a stiffer, more durable tubing which can be used instead of PVC for mainlines or sub-mains in larger installations. It joins together with a special machine which welds the joints and fittings. Low density polyethylene pipe is a flexible tubing which joins together by insert or compression fittings. Poly pipe has some resistance to ultraviolet light but should also be buried. Poly pipe is often used for mainlines, sub-mains and manifolds. Note: Always use stainless steel clamps for insert fittings, especially if the pipe is buried.

Trickle/Drip Tubing is thin- walled, polyethylene pipe which is very flexible and has good resistance to ultraviolet light (high in carbon black). This tubing is specially designed for trickle laterals and may have emitters already placed into the tube (in-line emitters) or emitters inserted on the outside. This type of tubing should have a lifespan of 20 to 25 years.

Linear drip tape is a very thin-walled plastic tape (tube) which has small holes throughout its entire length at specific intervals (see specific area drip in Figure 10). It is commonly used as a disposable type of watering system for annual row crops. The thickness of tape is directly related to lifespan and price (commonly sold by the pound). Common types of tape and their lifespan are: 4 millimetre lasts 1to 2 years; 8 millimetre lasts 3 to 4 years; and 12 millimetre lasts 5 to 7 years.

EMITTERS

There are several basic types of water delivery devices unique to micro-irrigation. They are designed to discharge water at low flow rates through small openings. The application rate of water is very small and slow, thus the name trickle or drip. The discharge rate is usually given in US gallons per hour (0.5 to 25 gph) or litres per hour. Operating pressure ranges between 2 and 60 psi depending on the type of emitter (see manufacturers' specifications), and can be pressure compensating which means discharge rates remain relatively constant over a range of pressures.

Point source emitters are small devices inserted or moulded into plastic pipe which apply water from a discrete a point This allows pinpoint watering to the root area of the plant (Figure 9). Some emitters are designed to self-flush at low pressure.

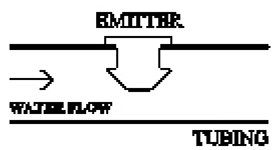

Figure 9: Inserted point-source emitter

Specific area drip, also known as linear drip tape, is small porous pipe commonly made from rubber, tyvac, paper, or plastic. Depending on soil texture, water spreads from the porous pipe to cover a specific planted area (Figure 10).

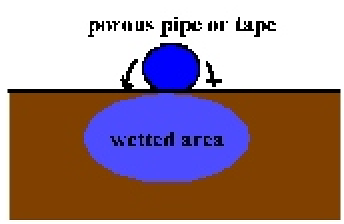

Figure 10: Specific area drip (porous pipe)

Spray emitters, or mini sprinklers, are small devices that imitate larger spray heads on a smaller scale (Figure 11). The wetted area is often larger due to higher flow rates than point source emitters. They are commonly used where a wash-down effect or syringing (cooling off) of plants is desired, and for frost protection

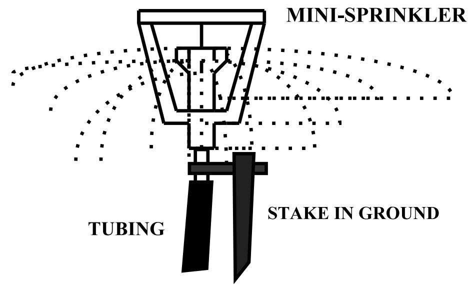

Figure 11: Mini-sprinkler

Bubblers have higher discharge rates (around 1 gallon per minute) than other common drip devices. They apply water as a small fountain or stream. Micro-bubblers are smaller versions of the traditional bubbler and have discharge rates of around 5 to 9 gallons per hour. These devices are ideal for larger trees or flower beds, but should have a small basin to contain water as the infiltration rate of the soil will probably be lower than the water application rate.

Sub-surface drip involves burying the dripper line. Often point-source emitter lines or specific area drip lines (porous pipe) are buried. There will be some movement of water upward due to capillary action. This will be governed by soil texture. There could be problems for germination of shallow seeded crops in coarse soils or if the drip line is too deep. The advantages of burying the drip line include reduced damage by tillage equipment, and longer pipe life due to protection from ultraviolet light. The problems with sub-surface drip are root-intrusion and not knowing whether drippers are plugged. One way to know if the drippers are plugged is to place a micro-spray emitter at the end of each lateral as it comes out of the ground. When the micro-spray is working, it indicates that the lateral line is working.

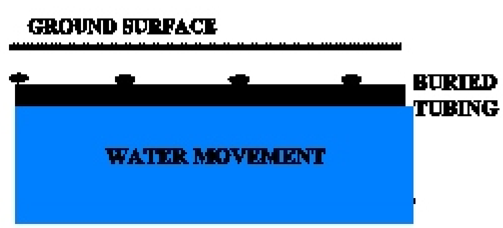

Figure 12: Sub-Surface Drip (Point-source Emitters)

SYSTEM DESIGN

DESIGN FACTORS

Design of a trickle irrigation system begins with gathering the information required for proper hydraulic design of the system. This information includes crop type and spacing; soil texture; climate factors; field size, shape and topography; and water source, quality and supply.

Crop type determines plant and row spacings (Table 3).

Table 3: Recommended plant and row spacing of various crop types.

Crop Type and Height	Plant Spacing	Row Spacing
Fruit Shrubs and Trees (2-5 feet)		
Raspberries	3 feet	10 feet
* Low Bush Blueberries	1 foot	4 feet
Fruit Shrubs and Trees (5-9 feet)		
Saskatoon Berries Choke Cherries Buffalo Berries Sea Buckthorn	3 - 5 feet	16 - 20 feet
Shelterbelt Trees		
Poplar Evergreen	10 -15 feet	10 -15 feet
Fruit Trees (9-20 feet)		
Pin Cherries Apple Trees Plum Trees	10 -15 feet	10-15 feet
Low Fruits and Vegetables		
• Wide Spacing •		
Rhubarb	3 feet	6 feet
Tomatoes	1.5 - 2 feet	4 feet
Cucumbers	1 - 1.5 feet	4 - 6 feet
• Close Spacing •		
Strawberries	0.5 - 1.5 feet	4 feet
Corn	0.6 - 0.8 feet	3 - 4 feet
Garden Vegetables		
Lettuce	Solid Row	2 feet
Carrots	Solid Row	2 feet

*Low bush blueberries must be burned every 2-3 years to enhance fruit development, therefore, emitter laterals of the trickle system must be buried to avoid damage (See sub-surface irrigation).

Field Size, Shape and Topography

A detailed sketch of the field should include field size, shape, topography (elevation changes), water and power source and soil type (refer to Figure 15). Draw a sketch of the field to scale and in relationship to direction north. The elevation changes of the field and the location of the water source will dictate the best direction to run laterals. For example, if the elevation changes in Figure 15 were greater, then laterals should be run east-west to reduce pressure variability. Try to group to laterals with similar elevation changes together for even flow distribution. Emitter placement on slopes is also important. If the emitter is placed below the plant on a downhill slope, there is a good chance the wetted area of the emitter will miss the plant. In such cases emitters should be placed above the plant (Figure 13).

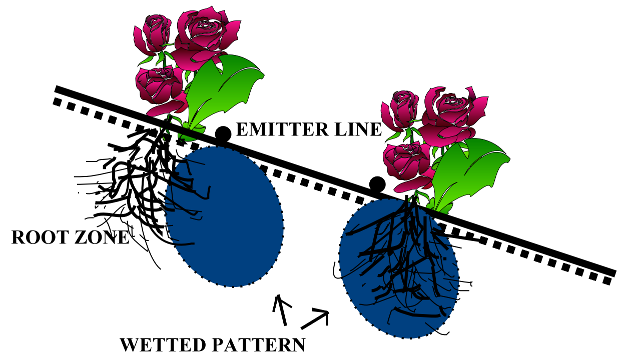

Figure 13: Emitter placement on slopes

SOIL TEXTURE will determine the number, discharge rate, and spacing of emitters. Water infiltrates different soil types at different rates and creates a different wetting pattern. In coarse, sandy soil water moves down with little outward movement (Figure 14). Therefore, to wet a large enough volume of the plant root zone, select emitters with higher discharge or choose a closer spacing. In fine, clay soil, water moves outward and downward at much the same rate. (Figure 14). To avoid puddling and run off when watering finer the soils, design emitters with a lower discharge or increase spacing of emitters (Table 4).

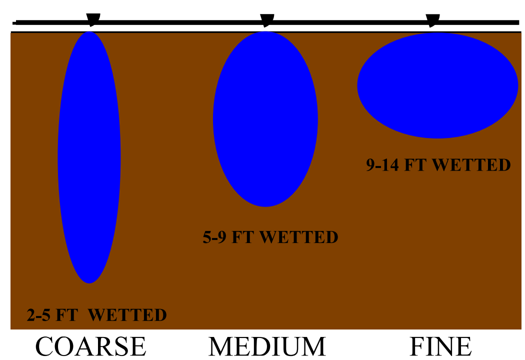

Figure 14: Wetting pattern in coarse, medium and fine soil.

Water Requirement of Plants and Emitter Selection

The following table has been developed to aid in general design of a trickle irrigation system. For larger acreages it is recommended that more detailed design factors such as potential evapo-transpiration rate, crop factor and irrigation efficiency be more precisely calculated by a professional irrigation designer or supplier (see Appendix 3 for a list of irrigation suppliers).

Table 4: General recommendations for plant water required, emitter flow, type and spacing

Crop Type and Height	**Soil Type**	**Water Required** gallons/day/plant	**Emitter Flow and Type** gallons/hour		**Emitter Spacing**
Fruit, Shrubs and Trees (2-5 ')	Coarse Medium Fine	1.5 gpd	1 gph 1-0.5 gph 0.5 gph	Point Source Point Source Point Source	2-3 feet 2-3 feet 2-3 feet
Fruit, Shrubs and Trees (5-9')	Coarse Medium Fine	4 gpd	1 gph 1-0.5 gph 0.5 gph	Point Source Point Source Point Source	2-3 feet 2-3 feet 2-3 feet
*Shelter-Belt Trees	Coarse Medium Fine	10 gpd	1 gph 0.5-1 gph 0.5 gph	Point Source Point Source Point Source	3 - 4 feet
Fruit, Shrubs and Trees (9-20')	Coarse Medium Fine	22 gpd	17-25 gpd	**Micro-sprays	In row half way between trees
wide spacing Low Fruits and Vegetables	Coarse Medium Fine	0.5 gpd	1.0 gph 0.5 gph 0.5 gph	Point Source Point Source Point Source	At plant At plant At Plant
close spacing	Coarse Medium Fine		0.5 gph	Point Source, Drip Tape or Micro-Sprays	1- 1.5 feet
Garden Vegetables **solid spacing**	Coarse Medium Fine	0.3 to 0.5 gpd per foot of row	0.2-0.5 gph	Point Source, Drip Tape or Micro-Sprays	1-1.5 feet

* Watering of shelterbelts for establishment and maintenance only.
**Micro-sprays are used because of high gallonage required for fruit trees of this size.

SAMPLE DESIGN: TRICKLE IRRIGATION SYSTEM FOR SASKATOON BERRIES

Step 1: **Determine water source; field location, size and topography; and soil type:**
Water source - Well (pump tests at 20 gpm), depth to water = 55 feet
Field location - SW-13-26-7-W3M
Field size - 240 feet x 250 feet
Field topography - see survey map of area (Figure 15)
Soil texture - sandy (coarse)

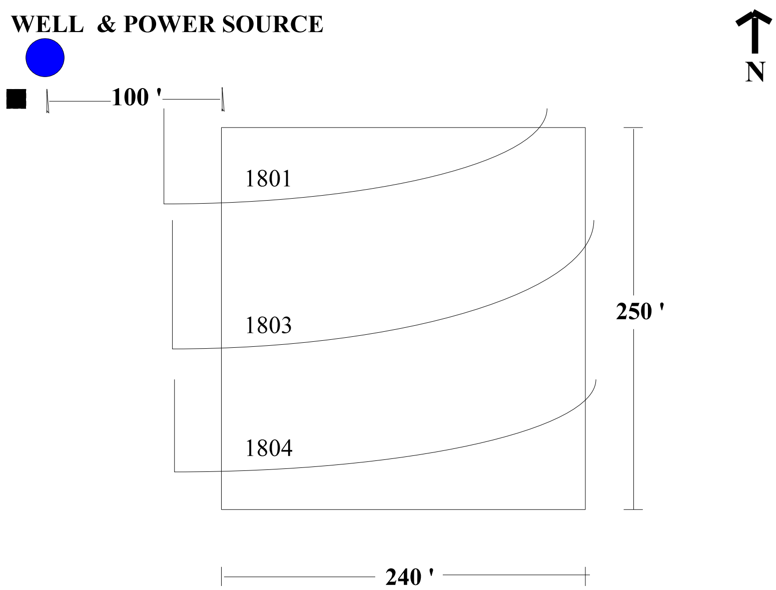

Figure 15: Preliminary Sketch of Field

Step 2: **Contact your local government agency who specializes in Irrigation (Appendix 2) for information on licensing approval for your project.**

Step 3: **Determine recommended plant spacing and row spacing for Saskatoon Berries (Table 3) and design field layout of irrigation system (Figure 16)**:
Plant spacing = 3 ft.
Row spacing = 20 ft.

Step 4: **Determine water required, emitter type, flow and spacing for Saskatoon Berry Fruit Shrubs 5-9' in height (Table 4):**
Water required - 4 gallons per plant per day
Emitter type - point source, pressure compensating between 15-50 psi
Emitter flow and spacing - 1 gallon per hour at 2 foot spacing

Step 5: **Calculate number of laterals and total system flow when all emitters are running:**

Field width / row spacing = # of laterals
240 feet/20 feet = 12 laterals

Row length = 250 ft
Emitter spacing = 2 ft
Emitter gallonage = 1 gallon per hour

Total system flow (gallons per minute) = # of laterals x (row length/emitter spacing) x emitter gallonage x 60 min/hr

∴12 x 250 feet/2feet x 1 gph x 60 = 25 gpm

Step 6: **Calculate system operating time:**

Water required = 4 gallons per day per plant
Plant spacing = 3 feet
Emitter flow = 1 gallons per hour
Emitter spacing = 2 feet

__________∴4 gpd per plant x 3 feet/2 feet x 1 gallon per hour = 6.0 hours

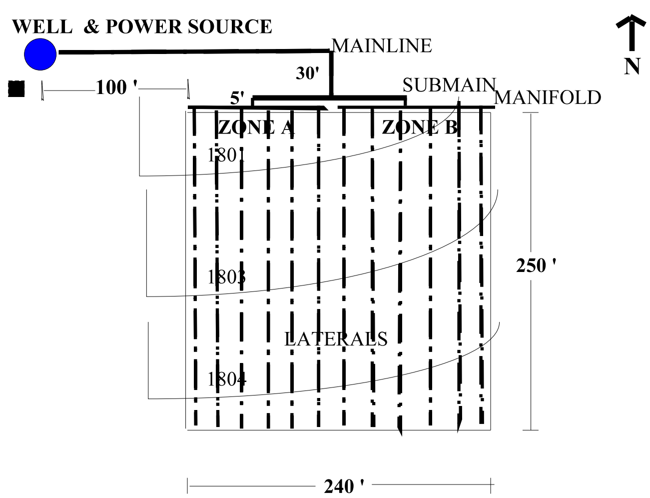

Figure 16: System Layout on Field

Step 7: Calculate # of zones required to irrigate the field:

Water source =20 gpm
Total system gpm = 25 gpm

∴25/20 = 1.25 zones (round up to 2 zones)

Step 8: Calculate flow requirements per zone:

Total system gpm = 25 gpm
# of zones = 2

∴25/2 = 12.5 gallons per minute per zone

Step 9: Calculate flow requirements per lateral:

laterals per zone = 12/2 = 6

gpm per zone/ # laterals per zone = flow per lateral
12.5/6 = 2.08 gpm per lateral

Step 10: Determine pipe size and pressure loss of lateral:

Lateral length = gpm per lateral/flow per emitter (gph) x 60 x emitter spacing = 2.08/1 x 60 x 2 = 250 feet

Lateral length = 250 ft
Flow per lateral (gpm) = 2.08 gpm

Manufacturers' recommendations are required for sizing of laterals because of the unique friction loss characteristics of the emitter barbs and roughness coefficients of different pipes. Basically, manufacturers will supply information for the longest length of run of a certain size pipe with a specific spacing of their emitters. A method of making a preliminary estimate of pressure losses is shown in Step 11 and in Appendix 4.

Step 11: Determine pipe size and pressure loss of manifold

Flow per zone = 12.5 gpm
Manifold length = field width/2 zones = 240 feet/2 = 120 feet per zone

Note: Since we are center feeding laterals with sub-main, we can size manifold pipe for half of flow per zone or 3 outlets in this case. Therefore the manifold length to use is 120 ft/2 = 60 feet and flow will be 3 laterals x lateral flow of 2.08 gpm. = 6.24 gpm.

From the chart (Appendix 1) we can use ¾ inch pipe with a pressure loss just over 3.43 psi per 100 feet.

Total psi loss in manifold = manifold length (feet)/100 feet x psi loss per 100 feet
Total loss in manifold = 60/100 x 3.43 = 2.06 psi loss for each side of manifold
The friction factor "F" (Table 2) for 3 outlets is 0.518.
Therefore the true friction loss will be 2.06 x 0.518 = 1.06 psi loss

Step 12: Determine pipe size and pressure loss of sub-main and mainline:
Total zone flow = 12.5 gpm (gallons per minute)
Total sub-main and mainline length = 315 feet

From Appendix 1 we determine a pipe size of 1½ inches with a pressure loss of just over 0.52 per 100 feet. Therefore, the total pressure loss will be 315 feet/100 x 0.52 = 1.64 psi loss in the sub-main and mainline.

Step 13: Determine filter requirements:
Flow per zone = 12.5 gpm
Water source is a well, low in biological and physical contaminants.

Select a screen filter sized for 12.5 gpm or higher according to manufacturers' specifications.

Step 14: Determine required fittings:
Fittings are determined by the type of material being used and according to where there has to be a connection (valve, filter, injector, etc.), direction change, reduction in pipe size, or a closure to a pipe end. See irrigation suppliers for help in selecting the proper fittings for the job.

Step 15: Pump sizing

Information Required for Proper Pump Selection:

1. **System operating pressure** is based on pressure required for emitters to operate properly. This information is obtained from manufacturer specifications.
2. **Total system pressure loss** is based on pressure loss due to friction of water flowing in system. Friction loss information for filters, valves and fittings can be obtained from manufacturers' specifications. Friction loss for mainline, sub-main and laterals can be calculated using charts in Appendix 1. Elevation loss or gain is calculated from a topographical map which is necessary if there are significant changes in elevation at the irrigated site.
3. **Suction lift** is based on the vertical distance from pump impellor to water level.
4. **Miscellaneous loss** - 10-15% is pressure loss due to pump wear and unknown losses.
5. **Power source** is electric, gas or diesel.
6. **Required flow** in gallons per minute for the largest zone in the system.

This information can be taken to irrigation or pump suppliers who will determine the best pump suited for your system as every pump is individually rated (see Appendix 3 for irrigation suppliers).

Step 16: List of Materials

Make a list and price all the materials needed for the job. Prices have not been included in the following table since they would be obsolete over time.

Table 5: List of materials required for sample design

Description	Size	Amount	Unit Price	Total Price
Low density poly pipe - mainline, sub-main	1½"	375 ft		
Low density poly pipe- manifold	¾"	240 ft		
Drip tubing - laterals (manufacturers' specs)	½"	3000 ft		
Pressure compensating emitters	1.0 gph	1500		
Emitter insertion tool (each manufacturer's emitter may have a different size barb)	for specific emitter	1		
Figure 8's (for lateral end closure) 	½"	12		
Combination nylon or poly insert tees (manifold to lateral connection)	¾" x ¾" x ½"	8		
Combination nylon or poly insert elbows (manifold to lateral connection-ends)	¾" x ½"	4		
Combination nylon or poly insert tee (sub-main to manifold connection)	1½" x ¾" x ¾"	2		
Nylon or poly insert elbow (mainline-sub-main)	1½"	3		
Nylon or poly insert tee (mainline-sub-main)	1½"	1		
Screen filter (150 mesh, max flow rate 28 gpm from manufacturer specs)	1"	1		
Vacuum flow breaker	1½"	1		
Stainless steel clamps	1- 1½ "	28		
Stainless steel clamps	½- ¾"	38		
Unions (filter to poly for easy removal)	1"	2		
Male adapter poly or nylon (union to poly)	1" male x 1½" insert	2		
Valves (mainline and on each side of sub-main)	1½ "	3		
Male adapter poly or nylon (valve connection)	1½"	6		
Valve boxes and filter box	medium	4		
Pump and required fittings as per suggested by pump supplier from Step 15				

ASSEMBLY, OPERATION AND MAINTENANCE

ASSEMBLY

1. Start assembly at the water source and continue to the laterals.

   IMPORTANT NOTE: At each step of assembly flush until water runs clean. This removes dirt, plastic pieces or small animals which may have contaminated the pipes or components during system installation.

2. Always wrap threaded connections with Teflon Tape (clockwise) to prevent leaky connections.

3. Many components have "direction of flow" arrows (filters, back flow preventors, pressure regulators and check valves). Keep this in mind when installing these components.

4. Lateral tubing may be connected to the manifold in different ways. They include an *insert or compression fitting* (used if manifold is 1" or less), *head connector*, which has an insert fitting on one end and barb fitting on the other for insertion into pre drilled or punched holes in manifold pipe (can be used on manifold 1" or more and must use gasket if going into PVC pipe). *Spaghetti tubing* is often used to connect low pressure drip tape to the manifold (insert a two-way barb emitter into manifold line to connect spaghetti tubing to, then cut a small hole in drip tape for spaghetti tube).

5. Lateral lines must be flushed throughout the growing season to keep the irrigation system clean and minimize emitter plugging. There are several methods used to close off the ends of laterals and the method chosen depends on the cost and how often lines will be flushed. Some of these methods include the *"figure 8" closure* which is most common and inexpensive, (slip bottom of "figure 8" fitting over the end of the tubing, bend tubing over and through top of "figure 8" fitting). *Wire or clamps* are sometimes used, but are more time consuming for opening lateral ends to flush. *Small valves* are a more expensive type of closure for lateral ends, but are very handy for flushing laterals which need cleaning more often.

6. Lateral lines should be immediately staked after being installed to prevent movement from contraction and expansion which occurs from temperature changes (day to night).

7. When the system is completely installed, leave lateral lines open, flush again and then close off while system is running.

8. Walk the system, check for leaks and replace any emitters not working or missing.

9. Adjust pressure regulators and control valves for proper flow and operation.

OPERATION

The operation of the trickle system involves determining how long and when to irrigate. This of course depends on crop demand (young or mature) and weather conditions. It is important to gather information and learn as much as possible about the crop you are growing. Provincial Agrologists, horticultural groups and experienced growers are good sources of information.

Many experienced growers learn to read a crop or probe the soil and know whether the crop needs watering. If you do not have this experience, there are many devices for monitoring soil moisture which can be used to help determine the need for watering. These devices include something as simply as taking a soil sample with a shovel or soil probe (feeling and smelling the soil for moisture) and other more common devices which can be automated to turn the irrigation system off and on. These devices include; tensiometers, evaporation pans, soil-moisture blocks, watermark sensors, automated atmometers, and time domain reflectometry. More information on these devices, contact your local Agriculture department.

Trickle irrigation offers the ability to maintain moisture in the root zone very near the optimum level for maximum crop growth. Automated systems can be set to irrigate any time soil moisture drops to a pre-set level, perhaps as often as several times per day. This is impractical for manually operated systems due to the labor necessary to determine if irrigation is needed and to operate the system. Trickle systems are usually designed to operate once per day, replacing the water used by the crop the previous day. Actual operation of most systems in the Prairie Provinces is more likely to be two or three times per week during hot weather in the summer months and less frequently when conditions are not as extreme.

Finer textured soils such as clay loam are able to absorb and hold greater amounts of water than can sandy loam or sand. However, they also hold onto that water more strongly. For most soils and situations we can estimate available soil water in saturated soil as one inch of water per foot of soil. With sprinkler irrigation growers determine the rooting depth of the crop, multiply that by the available water holding capacity of the soil and schedule irrigation when cumulative crop use since the last irrigation reaches that amount.

Because tickle irrigation only replenishes the moisture in part of the root zone (usually only 6 to 10 inches to either side of the tubing) and to make use of its ability to maintain uniform water availability, trickle irrigation should occur more frequently than sprinkler irrigation and should not be based on soil texture or rooting depth but on crop water use. Growers deciding to use soil moisture capacity as a guideline should limit soil moisture depletion to half of what is used for sprinklers. For sprinkler systems maximum recommended water depletion is fifty percent of available water. Therefore, for trickle limit that to twenty five percent.

Crop water use depends on temperature, humidity, wind speed, the age or size of the plants being irrigated and the stage of plant growth. High temperature, low humidity and high wind speed increase water use. Large plants and rapidly growing young plants use more water than small or mature plants that have finished their physical growth. Widely spaced plants will use less water per acre than closely spaced plants but not less on a per plant basis. A good example of that difference is the water use of saskatoon berry plants on a 3 foot by 20 foot spacing. If the inter-row area is kept cultivated and free of weeds the per tree and the per acre water use during the first few years of growth is very small: Less than 0.1 gallons per tree per day or about 73 gallons per acre per day. Mature saskatoon bushes will use up to 10 gallons per tree per day or 7300 gallons per acre per day.

Daily average water use during the May to September growing season will be between 0.2 and 0.25 inches for most areas of the Prairie Provinces. Maximum daily water use can exceed 0.3 inches. Row crops will have water use similar to solid seeded crops except where the row spacing is very wide. While no firm numbers are available some work by Sask Water agrologists suggests water use per acre will stay roughly the same until row spacing exceeds twice the height of the crop. At that point it will begin to decrease.

Fertigation is the application of fertilizer through the irrigation system during irrigation. Trickle irrigation works very well with fertigation because of its very accurate delivery of water and fertilizer to the plant. A fertilizer solution is injected into the trickle system with an injector pump (see section on chemical injectors) preferably before the filter. The fertilizer used can be either liquid fertilizer or soluble fertilizer mixed with water. Commercial granular fertilizer does not dissolve well enough to use in this manner.

The amount and analysis of the fertilizer used will depend on the crop being grown.

MAINTENANCE

A maintenance schedule for the trickle irrigation system should be set up immediately. Records of maintenance and performance should be kept on a daily or weekly basis to alert the operator of potential problems before they become costly problems. The following is a list of what to monitor on a trickle irrigation system:

1. Lubricate and check oil fill reservoir on the pump.

2. Check any electrical wires for damage. Rodents can chew on wires which are unprotected. It is a good idea to have traps or poison bait in the pump house to deter this damage or have wires installed in a sealed housing (such as another pipe) for protection from moisture, rodents and vandalism.

3. Listen to the pump for any unusual noises and check for vibration or leaks.

4. Check pressure gauges to insure normal operating pressure is maintained.

5. Check pressure regulators and control valves if pressure gauges are indicating unusual pressure readings.

6. Check all filter equipment and back flush or clean as necessary.

7. Flush drip laterals periodically. Two to three times a year is recommended.

8. It may be necessary to treat the water for organic growth or hard water buildup. Generally, **chlorine** is the most common chemical used to prevent the growth of algae, bacteria and fungi in trickle systems. These microorganisms can multiply rapidly due to the slow flow of water and can easily plug emitters if not controlled. Often chlorine is injected at the end of an irrigation cycle to provide residual treatment while the system is shut down.

   The amount of chlorine injected into the system depends on the concentration of the chlorine and flow rate of the irrigation system. The most common form of chlorine used is liquid sodium hypochlorite (household bleach) with stock concentrations of 5.25, 10 and 15 percent available chlorine. Chlorine treatment levels are given in parts per million (ppm) per gallons per hour (gph) of chlorine solution.

   Sulfuric and phosphoric acids are commonly used to combat problems of hard water scale build-up that is caused by calcium and magnesium carbonate precipitates. When the pH of water is lowered to about 6.5 (7 is neutral) precipitation is prevented. Injection points should be past metal connections and filters to avoid damage. **Remember: Always pour acid into water**. Never pour water into acid.

9. Winterizing the irrigation system involves draining and blowing lines with air. Put the system back together to avoid mice, etc. from getting in the system over winter. Be sure to leave valves part way open so they do not crack. Drain and lubricate the pump, and drain the filters and chemical injector or remove them for winter storage if outside. Be sure to plug any openings left in the system.

Appendix 1: FRICTION LOSS CHARACTERISTICS FOR POLYETHYLENE PIPE

POLYETHYLENE (PE) SDR-PRESSURE RATED TUBE
(2306,3206,3306) SDR 7,9,11.5,15C=140
PSI LOSS PER 100 FEET OF TUBE (PSI/100 FT)
Sizes ½" thru 4"; Flow GPM 1 thru 325

Size ID	½" 0.622		¾" 0.824		1" 1.049		1¼" 1.380		1½" 1.610		2" 2.067		2½" 2.469		3" 3.068		4" 4.026	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
1	1.05	0.49	0.60	0.12	0.37	0.04	0.21	0.01	0.15	0.00	0.09	0.00						
2	2.10	1.76	1.20	0.45	0.74	0.14	0.42	0.04	0.31	0.02	0.19	0.01						
3	3.16	3.73	1.80	0.95	1.11	0.29	0.64	0.08	0.47	0.04	0.28	0.01	0.20	0.00				
4	4.21	6.35	2.40	1.62	1.48	0.50	0.85	0.13	0.62	0.06	0.38	0.02	0.26	0.01				
5	**5.27**	**9.60**	3.00	2.44	1.85	0.76	1.07	0.20	0.78	0.09	0.47	0.03	0.33	0.01	0.21	0.00		
6	**6.32**	**13.46**	3.60	3.43	2.22	1.06	1.28	0.28	0.94	0.13	0.57	0.04	0.40	0.02	0.26	0.01		
7	**7.38**	**17.91**	4.20	4.56	2.59	1.41	1.49	0.37	1.10	0.18	0.66	0.05	0.46	0.02	0.30	0.01		
8	**8.43**	**22.93**	4.80	5.84	2.96	1.80	1.71	0.47	1.25	0.22	0.76	0.07	0.53	0.03	0.34	0.01		
9	**9.49**	**28.52**	**5.40**	**7.36**	3.33	2.24	1.92	0.59	1.41	0.28	0.85	0.08	0.60	0.03	0.39	0.01		
10	**10.54**	**34.67**	**6.00**	**8.82**	3.70	2.73	2.14	0.72	1.57	0.34	0.95	0.10	0.66	0.04	0.43	0.01		
11	**11.60**	**41.36**	**6.00**	**10.53**	4.07	3.25	2.35	0.86	1.73	0.40	1.05	0.12	0.73	0.05	0.47	0.02	0.27	0.00
12	**12.65**	**48.60**	**7.21**	**12.37**	4.44	3.82	2.57	1.01	1.88	0.48	1.14	0.14	0.80	0.06	0.52	0.02	0.30	0.01
14	**14.76**	**64.65**	**8.41**	**16.46**	**5.19**	**5.08**	2.99	1.34	2.20	0.63	1.33	0.19	0.93	0.08	0.60	0.03	0.35	0.01
16	**16.87**	**82.79**	**9.61**	**21.07**	**5.93**	**6.51**	3.42	1.71	2.51	0.81	1.52	0.24	1.07	0.10	0.69	0.04	0.40	0.01
18	**18.98**	**102.97**	**10.81**	**26.21**	**6.67**	**8.10**	3.85	2.13	2.83	1.01	1.71	0.30	1.20	0.13	0.78	0.04	0.45	0.01
20			**12.01**	**31.86**	**7.41**	**9.84**	4.28	2.59	3.14	1.22	1.90	0.36	1.33	0.15	0.86	0.05	0.50	0.01
22			**13.21**	**38.01**	**8.15**	**11.74**	4.71	3.09	3.46	1.46	2.10	0.43	1.47	0.18	0.95	0.06	0.55	0.02
24			**14.42**	**44.65**	**8.89**	**13.79**	**5.14**	**3.63**	3.77	1.72	2.29	0.51	1.60	0.21	1.04	0.07	0.60	0.02
26			**15.62**	**5.40**	**7.26**	**16.00**	**5.57**	**4.21**	4.09	1.99	2.48	0.59	1.74	0.25	1.12	0.09	0.65	0.02
28			**16.82**	**59.41**	**10.38**	**18.35**	**5.99**	**4.83**	4.40	2.28	2.67	0.68	1.87	0.29	1.21	0.10	0.70	0.03
30			**18.02**	**67.50**	**11.12**	**20.85**	**6.42**	**5.49**	4.72	2.59	2.86	0.77	2.00	0.32	1.30	0.11	0.75	0.03
35					**12.97**	**27.74**	**7.49**	**7.31**	**5.50**	**3.45**	3.34	1.02	2.34	0.43	1.51	0.15	0.88	0.04
40					**14.83**	**35.53**	**8.56**	**9.36**	**6.29**	**4.42**	3.81	1.31	2.67	0.55	1.73	0.19	1.00	0.05
45					**16.68**	**44.19**	**9.64**	**11.64**	**7.08**	**5.50**	4.29	1.63	3.01	0.69	1.95	0.24	1.13	0.06
50					**18.53**	**53.71**	**10.71**	**14.14**	**7.87**	**6.68**	4.77	1.98	3.34	0.83	2.16	0.29	1.25	0.08
55							**11.78**	**16.87**	**8.65**	**7.97**	**5.25**	**2.36**	3.68	1.00	2.38	0.35	1.38	0.09
60							**12.85**	**19.82**	**9.44**	**9.36**	**5.72**	**2.78**	4.01	1.17	2.60	0.41	1.51	0.11
65							**13.92**	**22.99**	**10.23**	**10.86**	**6.20**	**3.22**	4.35	1.36	2.81	0.47	1.63	0.13
70							**14.99**	**26.37**	**11.01**	**12.46**	**6.68**	**3.69**	4.68	1.56	3.03	0.54	1.76	0.14
75							**16.06**	**29.97**	**11.80**	**14.16**	**7.16**	**4.20**	**5.01**	**1.77**	3.25	0.61	1.88	0.16
80							**17.13**	**33.77**	**12.59**	**15.95**	**7.63**	**4.73**	**5.35**	**1.99**	3.46	0.69	2.01	0.18
85							**18.21**	**37.79**	**13.37**	**17.85**	**8.11**	**5.29**	**5.68**	**2.23**	3.68	0.77	2.13	0.21
90							**19.28**	**42.01**	**14.16**	**19.84**	**8.59**	**5.88**	**6.02**	**2.48**	3.90	0.86	2.26	0.23
95									**14.95**	**21.93**	**9.07**	**6.50**	**6.35**	**2.74**	4.11	0.95	2.39	0.25
100									**15.74**	**24.12**	**9.54**	**7.15**	**6.69**	**3.01**	4.33	1.05	2.51	0.28
110									**17.31**	**28.77**	**10.50**	**8.53**	**7.36**	**3.59**	4.76	1.25	2.76	0.33
120									**18.88**	**33.80**	**11.45**	**10.02**	**8.03**	**4.22**	**5.20**	**1.47**	3.02	0.39
130											**12.41**	**11.62**	**8.70**	**4.90**	**5.63**	**1.70**	3.27	0.45
140											**13.36**	**13.33**	**9.37**	**5.62**	**6.06**	**1.95**	3.52	0.52
150											**14.32**	**15.15**	**10.03**	**6.38**	**6.50**	**2.22**	3.77	0.59
160											**15.27**	**17.08**	**10.70**	**7.19**	**6.93**	**2.50**	4.02	0.67
170											**16.23**	**19.11**	**11.37**	**8.05**	**7.36**	**2.80**	4.27	0.75
180											**17.18**	**21.24**	**12.04**	**8.95**	**7.80**	**3.11**	4.53	0.83
190											**18.14**	**23.48**	**12.71**	**9.89**	**8.23**	**3.44**	4.78	0.92
200											**19.09**	**25.81**	**13.38**	**10.87**	**8.66**	**3.78**	**5.03**	**1.01**
225													**15.05**	**13.52**	**9.75**	**4.70**	**5.66**	**1.25**
250													**16.73**	**16.44**	**10.83**	**5.71**	**6.29**	**1.52**
275													**18.40**	**19.61**	**11.92**	**6.82**	**6.92**	**1.82**
300															**13.00**	**8.01**	**7.55**	**2.13**
325															**14.08**	**9.29**	**8.18**	**2.48**

Note: Bolded numbers on chart indicate velocities over 5 feet per second. **Use with Caution.**
Courtesy Rain Bird Corporation.

Appendix 2: Government Agencies

The licensing and management of irrigation projects is the responsibility of the provincial departments listed below:

Alberta

Alberta Agriculture Food and Rural Development, Irrigation Branch
Bag 3014, Lethbridge AB T1J 4C7
Phone: (403) 381-5140
Fax: (403) 381-5765
Email Address: www.agric.gov.ab.ca
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr8195?opendocument

Saskatchewan

Saskatchewan Agriculture and Food
Irrigation Development
Box 609, Outlook SK S0L 2N0
Phone: (306) 867-5500
Fax: (306) 867-9868
Email Address: gweiterman@agr.gov.sk.ca
http://www.agr.gov.sk.ca/docs/crops/irrigation/irrigationCert03.asp?firstPick=Crops&secondpick=Irrigation&thirdpick=Null

Manitoba

Manitoba Agriculture, Food and Rural Initiatives
Water Stewardship Water Branch
Box 44, 200 Salteaux Cres., Winnipeg MB R3J 3W3
Phone: 1-800-214-6497
Fax: (204) 945-7419
Email Address: wrb@gov.mb.ca
http://www.gov.mb.ca/conservation/watres/water_licensing.html

Canada

The Prairie Farm Rehabilitation Administration provides irrigation development information from many of their regional offices. For further information contact the PFRA office nearest you or the

Canada-Saskatchewan Irrigation Diversification Centre
901 McKenzie Street South
Box 700, Outlook SK S0L 2N0
Phone: (306) 867-5400
Fax: (306) 867-9656
Email Address: CSIDC@agr.gc.ca

Appendix 3: Trickle Irrigation Suppliers

Alberta

Alberta Irrigation Supply Ltd.
7026 30th Street
Calgary AB T2C 1N9
Phone: (403) 279-7673

A & D Irrigation
Box 1026
Fort MacLeod AB T0L 0Z0
Phone: (403) 553-2027
Fax: (403) 553-2027
Email Address: allanorr@bulli.com

Carlyle Company
#1-343 Forge Road SE
Calgary AB T2H 0S9
Phone: (403) 253-7100

Eljay Irrigation
405 33rd Street North
Lethbridge AB T1H 3Z6
Phone: (403) 320-1600
Fax: (403) 320-1673

Eljay Irrigation
3 - 3700 78th Avenue SE
Calgary AB T2C 2L8
Phone: (403) 279-2425
Fax: (403) 236-4248

Green Thumb Irrigation
7016 82nd Avenue
Edmonton AB T6B 0E7
Phone (780) 469-1222

New-Way Irrigation
Box 1889
Taber AB T0K 2G0
Phone: (403) 223-3591

New-Way Irrigation
2219 2nd Avenue North
Lethbridge AB T1H 0C1
Phone: (780) 328-3777

Regency Irrigation Ltd.
#5 - 2115 30th Avenue NE
Calgary AB T2I 6Z6
Phone: (403) 250-2685

South Alta Drip Systems
Box 1689
Fort MacLeod AB T0L 0Z0
Phone: (780) 553-4520

Total Distributors
Box 87, Station I
Edmonton AB T6C 4J5
Phone: (780) 438-6825

Water Wick Inc.
Box 465
High River AB T0L 1B0
Phone: (780) 625-3289

Windy Ridge Nursey
Box 301
Hythe AB T0H 2C0
Phone: (780) 356-2167

Waterberri Industries
200 - 222 16th Avenue NE
Calgary AB T2E 1J8
Phone: 1-800-344-4216
Fax: (403) 778-0884

Saskatchewan

Anderson Pump House Ltd.
192 4th Avenue
Battleford SK S0M 0E0
Phone: (306) 937-7741
Fax: (306) 937-3766

Anderson Pump House Ltd.
365 36th Street West
Prince Albert SK S6V 7L4
Phone: (306) 764-6639
Fax: (306) 763-0663

C & F Installations Ltd.
610B 51st Street East
Saskatoon SK S7K 7K3
Phone: (306) 931-8755
Fax: (306) 934-2464

Eljay Irrigation
#4-811 51st Street East
Saskatoon SK S7K 5C7
Phone: (306) 931-2440
Fax: (306) 931-4955

John's Nursery and Garden Centre
Box 24
Henriburg SK S0J 1C0
Phone: (306) 764-8139
Fax: (306) 764-8153

Kel-Tech Irrigation
Box 775
Outlook SK S0L 2N0
Phone: (306) 243-2166
Fax: (306) 243-2166

Rain Maker Irrigation Development Ltd.
Saskatchewan Road
Box 1308
Outlook SK S0L 2N0
Phone: (306) 867-9606
Fax: (306) 867-9271

Consolidated Turf Equipment Ltd.
144 Cardinal Crescent
Saskatoon SK S7L 6H6
Phone: (306) 653-5444
Fax: (306) 664-1934

Valley West Irrigation
50 Saskatchewan Road
Box 670
Outlook SK S0L 2N0
Phone: (306) 867-9252
Fax: (306) 867-8945

Water Boy Supply Centre Ltd.
1316 Hamilton Street
Regina SK S4R 2E5
Phone: (306) 757-6242
Fax: (306) 347-7992

Waterberri Industries
Box 1131
Swift Current SK S9H 3X3
Phone: 1-800-344-4216
Fax: (306) 778-0884

Manitoba

All-Tech Irrigation Services
64 Southside Estates
Ile Des Chenes MB R0A 0T0
Phone: (204) 878-3909

Consolidated Turf Equipment
986 Powell
Winnipeg MB R3H 0H6
Phone: (204) 632-7643

Eljay Irrigation
37 Keith Road
Winnipeg MB
Phone: (204) 694-9442
Fax: (204) 694-4072

Evenspray and Chemical Ltd.
851 Lagimodier
Winnipeg MB
Phone: (204) 237-9095

Ful-Flo Industries Ltd.
Perimeter and Highway 7
Winnipeg MB
Phone: (204) 633-4414

Appendix 4: Preliminary Estimate of Pressure Losses
(Supplement to calculations shown in Steps 10 to 15 in design example)

Prepared by Lloyd Barteski, P.Eng., C.I.D. (Drip/Micro)

Appendix 4 briefly shows a method for determining the pressure losses for the example trickle system described in the manual. Calculation of the flow requirements and pressure losses allow the pumping unit size to be determined. These calculation are preliminary, but give a reasonable idea of the final system characteristics. A final design would use actual performance characteristics for the equipment being used on the project and the results from field testing and surveys.

a. Losses in the Lateral

given: Pressure compensating emitters capable of supplying 1US gph over an operating pressure range of 15 psi to 50 psi

Average lateral length = 250 feet

Flow per lateral = 2.08 gpm

Number of emitters per lateral = 250/2 = 125 emitters per lateral

b. Calculation of Lateral Inlet and End Pressures

Assigned average pressure in lateral = 20 psi

For a one pipe size lateral the average pressure is related to lateral inlet pressure and the end of lateral pressure as follows:

$H_I = P_{ave} + 0.75\ H_L \pm 0.5\ \Delta E + H_M$

$H_o = P_{ave} - 0.25\ H_L \pm 0.5\ \Delta E - H_M$

$H_I = P_o + H_L \pm \Delta E + H_M$

H_I = inlet pressure

H_o = end of lateral pressure

ΔE = elevation difference along lateral

H_L = lateral friction loss

P_{ave} = average emitter pressure

H_M = minor losses

Note: Minor pressure losses due to emitter barbs can be estimated at 30 percent of pipe friction losses. Losses due to barbs, filters, pressure regulators, injectors or chlorination equipment are calculated along with pipeline friction losses. Minor losses in the manifold, sub main, mainline and suction pipe due to connectors, valves, etc. are estimated as 10% of total losses when determining TDL and pump size.

given: Average lateral length (average for zone) = 250 feet

Lateral hose diameter 0.622 inches I.D. (normal ½ inch pipe, a common size)

Average pressure = P_{ave} = 20 psi (assigned by designer)

Number of emitters per lateral = 125

Lateral flow = 2.08 USgpm

1. Elevation difference along lateral (as per Figures 15 and 16)
   Zone A = 1085 - 1800 = 5 feet uphill ∴ $\triangle E$ = 2.2 psi
   Zone B = 1806 - 1800 = 6 feet uphill ∴ $\triangle E$ = 2.6 psi

2. Pipe friction loss H_F (as per Appendix 1)
   H_f @ 2.08 USgpm for normal ½" diameter tubing = 1.76 psi per 100 feet
   H_f = (1.76/100) (250) = 4.4 psi for pipeline without multiple outlets
   H_f is pipe friction loss without outlets, consider each emitter an outlet and refer to Table 2
   Number of outlets = 125 so F = 0.338
   H_L= F H_f = 0.338 (4.4) = 1.5 psi

3. Minor losses (due to barbs, connectors, etc. in lateral)
   H_M = 30% of 1.5 psi = 0.5 psi
   Assume half of the barb losses occur upstream and downstream of the emitter with the average pressure

.

4. Lateral inlet and end pressure
   H_I = 20.0 + 0.75 (1.5) + 0.5 (2.6) + 0.25 = 22.7 psi
   H_o = 20.0 - 0.25 (1.5) - 0.5 (2.6) - 0.25 = 18.1 psi

Both inlet and end pressures are within the operating range of the pressure compensating emitters. In a more detailed design, an evaluation of pressure and flow variation along the lateral and of water distribution uniformity across the zone would be recommended.

c. Calculation of Manifold Pressure Losses

given: Manifold length = 120 feet

Manifold length from junction with sub main to manifold end = 60 feet

Number of outlets from sub main to manifold end = 3

Manifold flow = Q = 3 x 2.08 = 6.24 USgpm

Pipe size = ¾ inch 0.824 diameter

Multiple outlet friction loss factor (Table 2) = F = 0.518

1. Elevation difference along manifold
   Zone A = 1800 - 1800 = 0 feet (0 psi)
   Zone B = 1800 - 1800 = 0 feet (0 psi)

2. Manifold pipe friction loss (as per Appendix 1 and Table 2)

$$H_L = F\ H_f = 0.518\ (343/100)\ (60) = 1.1\ \text{psi}$$

- Minor friction losses and secondary filter losses

  Minor losses in the manifold are be calculated in Appendix 4.e. The pressure drop across the secondary filter, as recommended by the filter manufacturer (assumed to be 5 psi in this example).
  $H_M = 5.0$ psi

4. Manifold inlet pressures and flow

   Manifold outlet pressure is equal to the lateral inlet pressure calculated in Appendix 4.b.4
   $H_{M0} = 22.7$ psi
   $H_{MI} = H_l + H_L \mp \Delta E + H_M$
   $= 22.7 + 1.1 + 0.0 + 5.0 = 28.8$ psi

   Flow into each zone to supply all laterals in the zone
   $Q_{ZA} = 6 \times 2.08 = 12.48$ US gpm
   So upstream of each zone's secondary filter the flow and pressure is 12.5 US gpm @ 28.8 psi

d. Calculation of Sub Main and Main Pipeline Pressure Losses

The pipeline from the manifold to the main pipeline is called the sub main. In this example the sub mains for both Zone A and Zone B are the same size since the flow to each zone is the same. Since only one zone operates at a time, the size of the main equals the size of the sub main, in this example.

given: Main and sub main length = 315 feet
Total flow in sub main and main line = 12.5 US gpm
Normal pipe size = 1.5 inches (ID = 1.380 inches)

1. Elevation difference along sub main and main line
   Zone A + Zone B elevation = 1800 feet
   Pump elevation = 1800 feet

Assumed draw down in well $\vartriangle E_D$ @ 12.5 US gpm discharge = 20 feet

Note: The well's flow and draw down will have to be proven by a hydrogeology evaluation and actual pump tests.

$\vartriangle E$ = 1800 - 1800 = 0 feet (0 psi)
$\vartriangle E_D$ = 1800 - 1780 = 20 feet (8.7 psi)

2. Pipe friction losses (Appendix 1)
   @ 12.5 US gpm, H_f = 0.52 psi per 100 feet
   H_L = (0.52/100) (315) = 1.6 psi

3. Minor friction losses along sub main and main

   Minor losses in the manifold will be calculated in Appendix 4.e. The primary filter is assumed to be a sand or media filter. The actual pressure drop across the filter is recommended by the filter manufacturer (for
   this example it is assumed to be10 psi)
   $H_M = H_{filter}$ = 10.0 psi

4. Pressure losses in sub mains and main pipelines
   H_M = 0 + 1.6 + 10.0 = 11.6 psi

e. Pump Unit Calculation

Maximum capacity required - 12.5 US gpm		
Pressure required at zone		28.8 psi
Head loss in main pipelines	11.6 psi	
Static lift (draw down)	8.7 psi	
Miscellaneous losses (10% of total losses)		5.0 psi
Total Dynamic Head (TDH)	51.4 psi (125 feet)	

Pump efficiency (Eff%) 50%

$$\text{Horsepower required} = \frac{(TDH)\ 2.31Q}{3960\ (Eff\%)} = \frac{(54.1)\ 2.31\ (12.5)}{3960\ (0.50)}$$
$$= 0.80 \text{ BHP Continuous}$$

f. Manufactures' Specification and Design Criteria

Manufacturers' specifications and design criteria should be followed to calculate filter, injector, and chlorination equipment sizing.