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Low Pressure Drip Irrigation--Concept and Description

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INTRODUCTION

Since its introduction in the 1960's, the availability, quality, management and performance of drip irrigation (DI) and subsurface drip irrigation (SDI) have greatly improved. The uses of DI and SDI have increased significantly as understanding and benefits of real-time irrigation methods increased and plastic materials availability, manufacturing processes, emitter designs and fertilizers improved. However, the perceived high initial cost of DI and SDI systems have slowed down the conversion of gravity irrigation to these systems. The low pressure system (LPS) is a systematic development of a low cost DI system which performs as DI except that the water is applied 3-4 in. (0.08-0.10 m) below the soil surface through discrete emitters, with a wide ranges of discharge rates and spacings. The low pressure capability of LPS (2-3 psi; 0.14-0.21 kg/cm^2) provides an effective low energy and economical upgrade for furrow irrigation. Furthermore, LPS mitigates environmental issues arising from difficult-to-control surface irrigation, non-point source pollution, deep percolation of soluble salts and pesticides, erosion and sedimentation of watersheds. The introduction of LPS provide an alternative initial low cost systems with a multiyear life expectancy displaying a number of advantages associated with permanent DI and SDI systems.

CONCEPT

The major objective of LPS is to provide a one-to-three year life span irrigation system with water and fertilizer application advantages of DI and SDI systems but at a lower initial cost, although the initial LPS cost is dependent on the sophistication level of the LPS. Conceptually, LPS is specifically designed to: (1) help growers use existing infrastructures such as leveled fields, water sources and pumps, (2) minimize front end investment (3) provide fast return on investment, (4) reduce energy cost for pumping and pressurizing, (5) move and reuse equipment easily and (6) provide low system maintenance and management. Two visualized additional advantages of LPS could be: (1) low pressure/low flow design suggests that LPS could operate similarly to furrow irrigation by applying water uniformly over 1/4 mile- (400 m)-long rows and thus could potentially replace large Western furrow irrigated acreage and (2) water discharge rates being lower than most soil infiltration rates would not require the use of rigorous high frequency irrigation scheduling (LPS can stay on for longer periods of time without creating runoff and/or deep percolation). As an example, Figure 6 shows the downstream end of a uniform potato field (800 ft. long; 250 m) irrigated by a LPS in the Arava Valley, Israel. The water distribution and the potato crop canopies are highly uniform across the whole field.

Components of a Typical LPS System

A typical LPS consists of several specific components. Depending on the size of the system, the topography of the site, the soil characteristics, the crop, the water/fertility requirements, the water source, availability and/or quality or the application considered, LPS may vary considerably in physical layout but generally will basically consist of some of the components shown in Figure 1, although LPS will often be as simple as the system shown in Figure 2. The various components of the system can be added as desired and are divided into: (1) connection to water source, (2) control headworks including a fertigation system, (3) field distribution system, (4) dripperline laterals, (5) accessories and installation tools and (6) optional automation and instrumentation. These components will be briefly described and discussed below:

1. Connection to Water Source

a. Alfalfa Valve--Many furrow irrigation systems are using alfalfa valves to deliver irrigation water from an elevated reservoir to gated pipes, head ditches and hand siphons. Assuming that the steady state static pressure from the reservoir is at least 7-8 ft. (2.1-2.5 m), alfalfa valves, fitted with a bell coupling, provide an ideal water supply connection for the LPS.

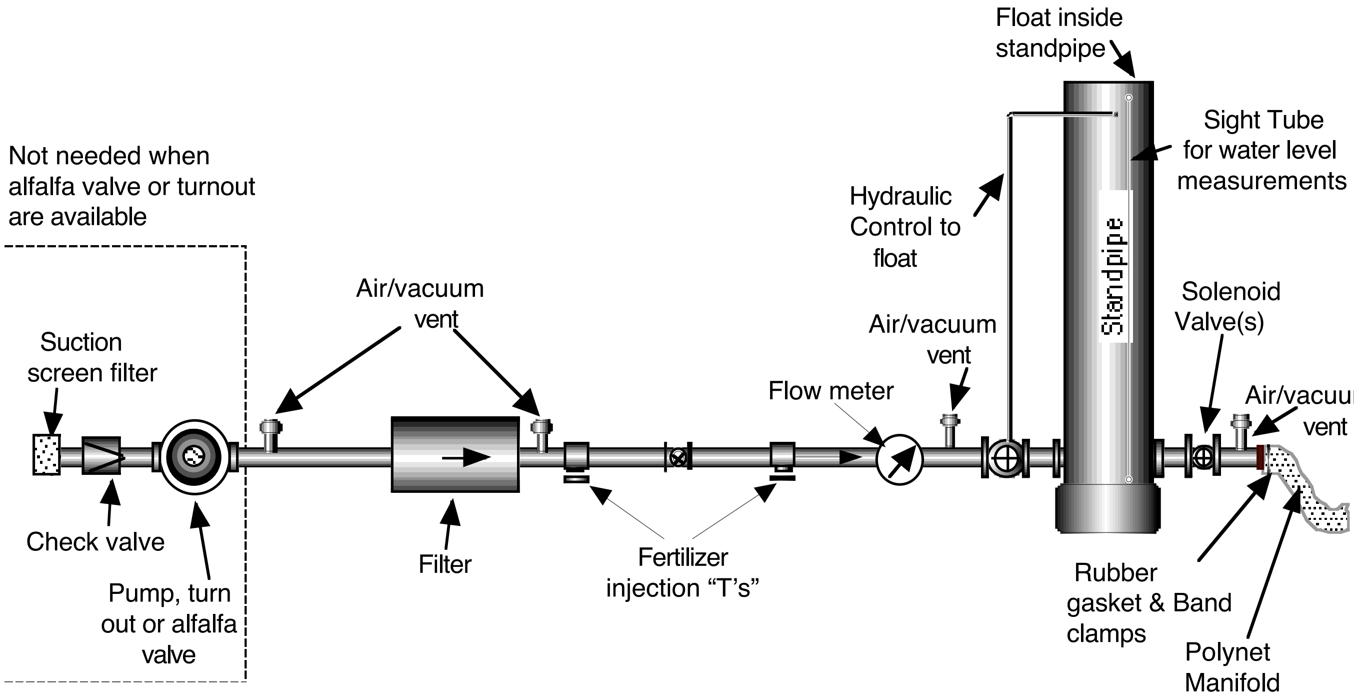


Figure 1. Headworks components for a basic LPS system.

b. Reservoir and Pump--Many farms are storing water in elevated reservoirs to supply water on-demand to their irrigation systems and will not required a pump if the reservoir static pressure is at least 7-8 ft. (2.1-2.5 m). In cases where the static pressure from the reservoirs do not meet this minimum pressure requirement, a pump can be used to supply pressurized water for the LPS.

c. Direct Connection to a Pressurized System--Many Irrigation Districts are supplying pressurized water to on-farm turnouts to supply water on-demand for their irrigation clients. In these cases, a pump may not be required if the static pressure from the turnout is at least 7-8 ft. (2.1-2.5 m). In cases where the static pressure from the irrigation district does not meet this minimum pressure requirement, a pump could be used to increase the water pressure for the LPS. Figure 2 shows a basic example of an on-farm low pressure water turnout supplying water for a LPS via a screen filter and a pressure regulating standpipe.

2. Control Headworks

The headworks of a basic LPS consists of specific components, as shown in Figure 1. Depending on the type of LPS used, the topography of the site, the soil characteristics, the crop, the water/fertility requirements, the water source, availability and/or quality or the application considered, field systems may vary considerably in physical layout but generally will consist of the following or some variations of the following components:

a. Air vents-- Air vents are a critical component of any hydraulic network. In its natural liquid state, water contains 2%-3% of dissolved air. As water temperature rises and/or pressure in the line drops, this dissolved air is released from the water in the form of small bubbles. The air bubbles expand and rise to the top of the pipe and accumulate at elbows and high points in the system. If not released, air pockets are formed, reducing the effective diameter of the pipe. Hence, the use of air relief valves at all high points of the LPS is the most efficient way to control air. There are three major types of air vents: (1) Air/Vacuum Relief Vents, also known as kinetic air valves. These air vents discharge large volumes of air before a pipeline is pressurized, especially at pipe filling. They admit large quantities of air when the pipe drains and at the appearance of water column separation; (2) Air Release Vents are also known as automatic air valves. These vents continue to discharge air, usually in smaller quantities, after the air vacuum valves close, as the line is pressurized and (3) Combination Air Vents, also known as double orifice air valves, fill the functions of the two types of air vents described above.

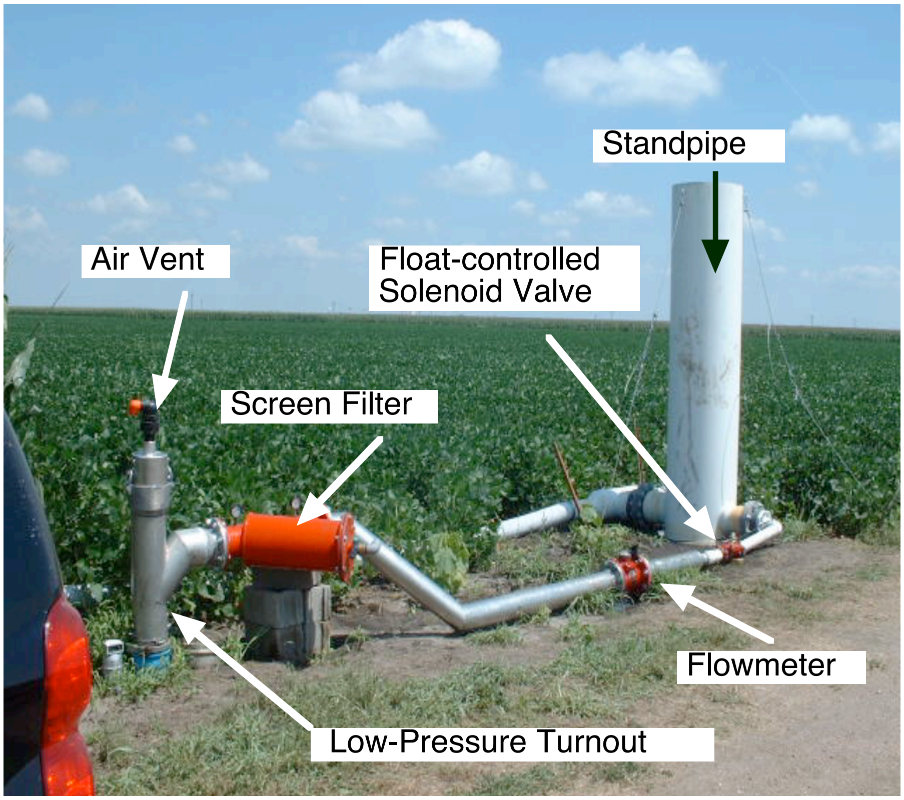


Figure 2. A low pressure turnout and screen filter supplying water to a LPS-irrigated soybean crop at the University of Nebraska, South Central Lab, Clay Center NE.

b. Filter--The main purpose of filtration is to keep mainlines, submains, laterals and emitters clean and working properly. It is critical with LPS because of their low available flushing velocity. Physical, chemical and biological clogging factors can and must be prevented by proper filtration and water treatment.

Many factors affect the selection of a filtration system. Designers should use the correct equipment for a specific farm water source. With LPS, the choice of a filtration system is further limited by the availability of electrical power and hydraulic pressure. Screen filters, such as shown in Figure 2 (raise the LPS required pressure) and gravity filters (low pressure) have been used with LPS.

c. Flowmeter--Knowing how much water and when it is supplied are critical measurements for correctly operating LPS irrigation. Inline flow meters should record total flow and flow rate both visually and electronically. With LPS it is also recommended to use several single lateral electronic flowmeter so that small flow rate changes can be detected and corrected at the onset of the occurrence

d. Float Control Valve--The main solenoid valve is controlled by a float, located in the standpipe at the preset maximum water level. The valve solenoid is hydraulically controlled by the float and opens or closes to maintain a constant water level and head pressure on the downstream LPS system.

e. Standpipe--The main purpose for the standpipe is to accurately control the pressure applied to the LPS dripperlines. Typical standpipes are 10.7 ft. high by 2.25 ft. diameter (3.25 m x 0.69 m) with inlet and outlet flanges. Water level and downstream pressure control are achieved by using a float which activates the float control valve shown upstream of the standpipe in Figure 2. A clear, external water level tube allows the operator to visually determine the water level in the standpipe. Inlet and outlet pipes are connected to the standpipe by bolted flanges. In areas where wind gusts are occurring, the standpipe can be anchored to the ground by three or more steel cable ties.

f. Fertilizer Injector--Fertilizer injection methods range from dripping fertilizers at calculated rates into the standpipe (no available electrical power or necessary pressure) to using fully computerized monitoring and control systems. When electrical power is available, injecting with metering pumps is the most versatile method for injecting chemicals into LPS systems. Automatic time and programmable controllers are usually the best way to control fertilizer injection. When full automation is used, the metering of the fertilizer is programmed for injection during the middle of the irrigation cycle to avoid the line filling time of the irrigation cycle. Injection of chemicals can also be stopped during filter flushing operations. Continuous measurements of pH and EC_w are also recommended to ensure adequate system performance and to control the pump on or off and/or in the case of accidents and malfunctions. Figure 3 shows a recommended design for safely controlling the injection of multiple nutrients and acid.

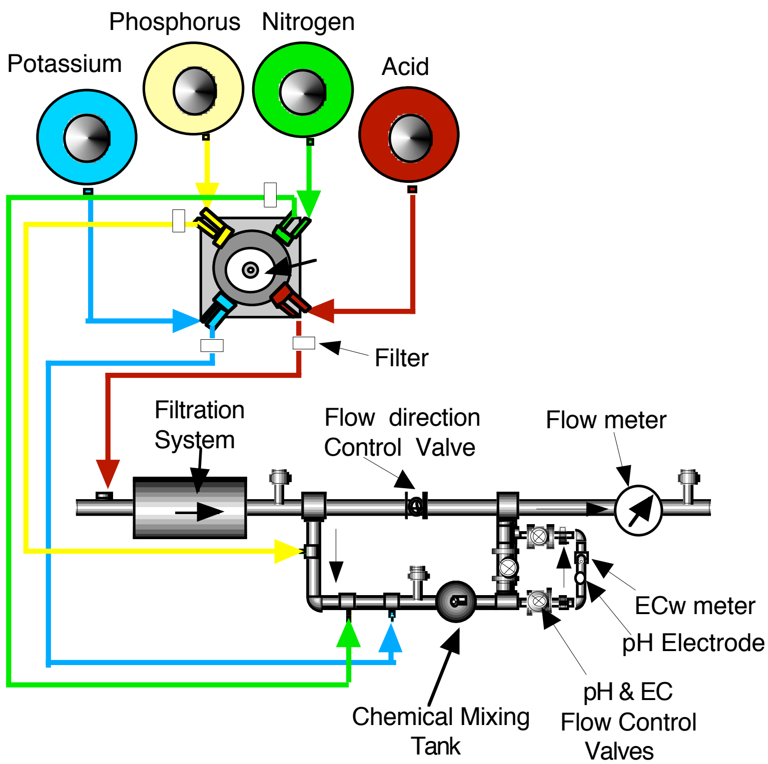


Figure 3. A recommended design for safely controlling the injection of multiple nutrients and acid into a LPS.

g. Pressure gauges/transducers--The sight tube mounted on the standpipe provides a good estimate of the pressure applied to the LPS, although pressure gauges with a range of 0-15 psi can also be used at several points in the headworks. Electronic pressure transducers are also available for input into a controller but are presently relatively expensive.

h. Field Solenoid Valve and Flowmeter/Polynet Submains/Manifolds--
Field solenoid control valves, each with an individual flowmeter and connections to several Polynet submains/manifolds can be set up for a large field application requiring several irrigation sets.

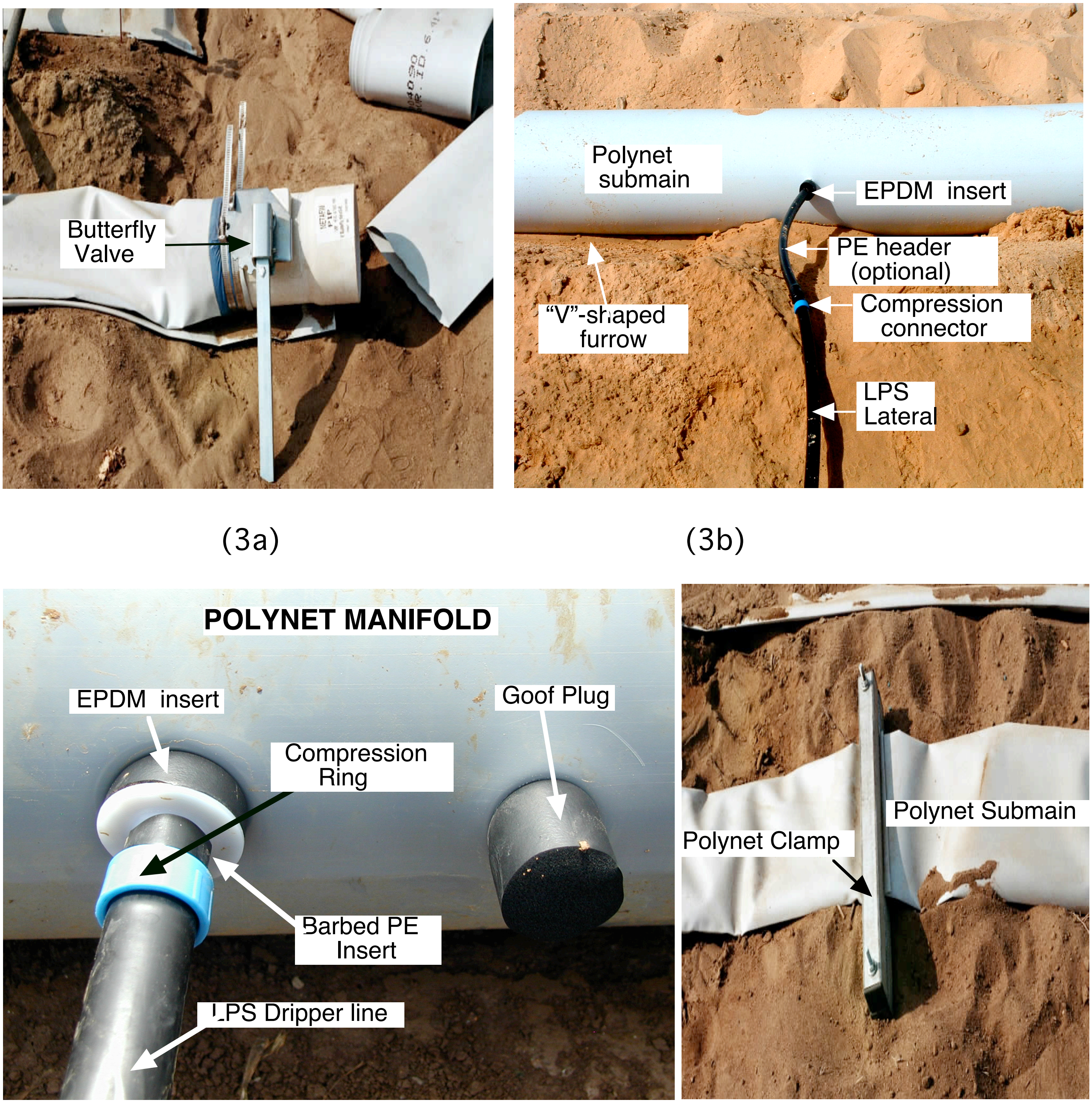
3. Field Distribution System
The field distribution system consists of (1) solenoid or manual valves, (2) Polynet submains/manifolds with its EPDM lateral connectors, (3) air vents and (4) manual clamps. Figure 4 shows a photograph of a manual valve for a distribution manifold (3a), a connection to a Polynet submain/manifold with a flexible PVC header tube (3b), a close-up of Figure 3b with direct connection of the dripperline to the EPDM insert (without the flexible PVC header tube) (3c) and a simple wood or metal clamp that can also be used as a manual feed or flush valve (3d).

4. Laterals
Depending on the type of LPS applications, there are several types of thin-wall dripperlines with emitters integrated within the pipe wall that are available for LPS. The available types of LPS dripperlines are based on life expectancy (1-3 years) and types of tillage application. Emitters with different flow path configurations, discharge rates and operating pressure range are presently tested in LPS dripperlines.

5. Accessories and Installation Tools
a. Tractor and Implements--A standard field tractor with a twin shank injection implement can be used for installation of LPS dripperlines, although larger tractors and implements are also being used.
b. Punch Tools, gaskets and Adjustable Band Clamps, etc...--Necessary hand tools and accessories to install LPS system are now commercially available. They include the hole punch to install LPS EPDM connectors to the Polynet manifold, adjustable band clamps to secure the Polynet manifold to the PVC pipes, rubber gaskets that fit between the Polynet and the PVC pipe and miscellaneous parts to help the LPS perform as specified.

6. Automation and Instrumentation
Full automation of LPS is available, although strictly an option. Because LPS applies water at a rate usually lower than the soil infiltration rate, high frequency irrigation management is not necessary to prevent runoff and/or deep percolation. Hence irrigation scheduling is typically less complicated and intense than for DI and SDI. However, although optional, instrumentation to measure weather and soil water conditions or access to a system that does (State Weather Network) can help meet the rapidly changing evapotranspiration demand of the crop and improve water use efficiency.

Ensuring adequate LPS operation also benefits from continuous measurements of water flow and pressures to determine water availability, broken lines and/or small changes which might be caused by plugging due to root intrusion, soil accumulation in the flow path of the emitters, biological growth and/or chemical precipitation. Changes in water quality due to source changes and mixing of waters and fertilizers may also require pH, water temperature and EC_w measurements in real time. The logic of an optional automation system capable of performing these functions automatically is available and shown in Figure 5. The typical components for a remotely accessible, real time/feedback automated control system can be added at any time to the LPS.



(3a) (3b)

(3c) (3d)

Figure 3. Photograph of a manual valve for a distribution manifold (3a), a connection to a Polynet submain/manifold with a flexible PVC header tube(3b), a close-up of Figure 3b with direct connection of the dripperline to the EPDM insert (without the flexible PVC header tube) (3c), and a simple clamp that can be used as a valve (3d).

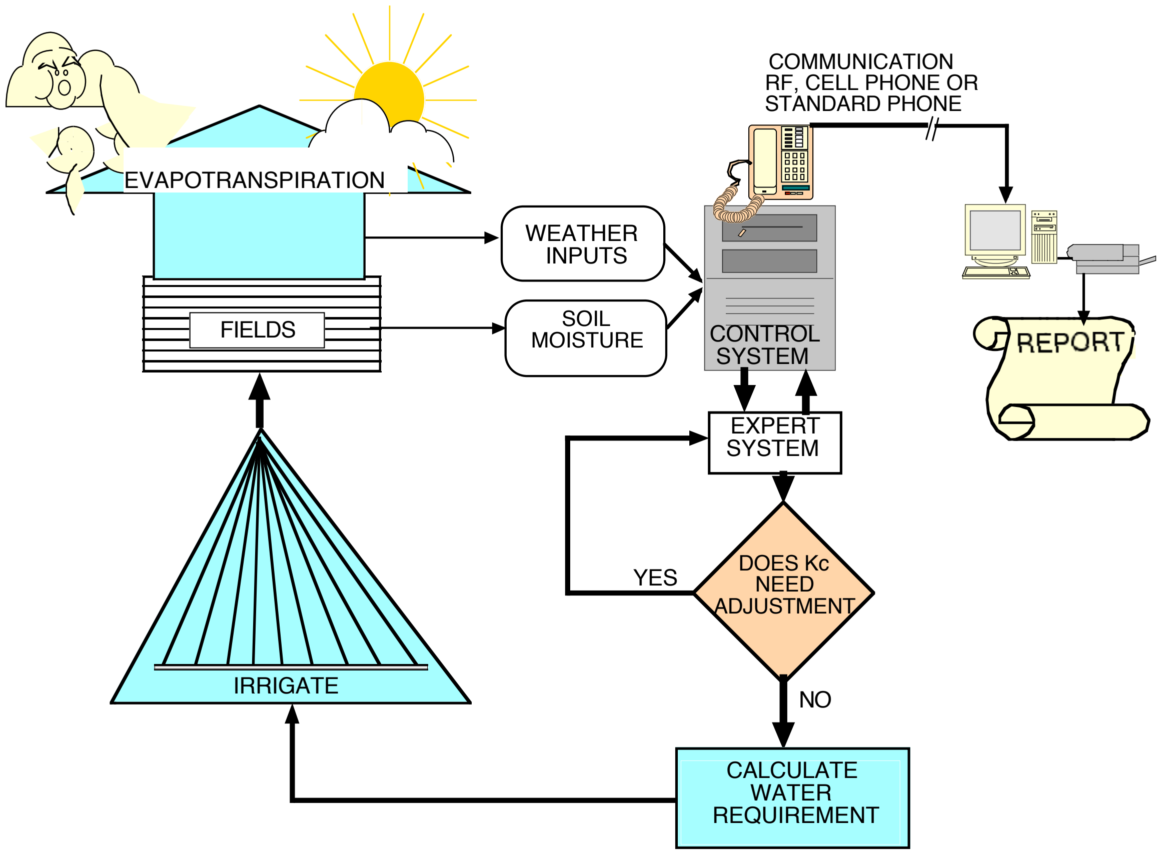


Figure 5. Logic for a remotely accessible and real time/feedback automated control system.

CONCLUSION

Several statistically designed and replicated LPS projects were conducted in cooperation with university extension staffs in Arizona, Arkansas, California (cotton) and Nebraska (soybean). At writing time, although final results are not yet available, preliminary results indicate that LPS can operate and perform as specified. Some final results will be presented at the IA Technical conference. Initial results point out the importance of the management of water quality and volume, dripperline installation and location with respect to the plants and measurements of volume and rate of water application. The management advantages of automation, real time soil moisture monitoring and computerized fertigation were clearly demonstrated in the California project at UC Shafter Cotton Research Center. There, the LPS laterals will remain in the field and minimum tillage practices will be carried out to test the potential of dust reduction. These projects will be repeated for an additional two to three years to validate the life expectancy of the dripperlines and to define the conservation and water use efficiency aspects of the method.

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Figure 6. The downstream end of a large potato field (800 ft. long; 250 m) irrigated by LPS in the Arava Valley, Israel .