

Potential Impacts of Improper Irrigation System Design¹

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Introduction

Proper design of irrigation systems is critical to achieving optimal plant growth and yield and minimizing negative impacts on natural resources, the environment, and the economy (Bayabil et al. 2020a). Irrigation systems with improper design could have several negative impacts such as waste of freshwater resources, water quality deterioration, risks to operator safety and public health, and economic losses (e.g., increased cost of irrigation, loss of economic return from irrigation, and reduced irrigation system life expectancy). This publication discusses a few major consequences of improper irrigation design. The goal of this article is to summarize major consequences that could arise from improper irrigation designs. The target audience includes students, Extension agents, growers, homeowners, and irrigation contractors.

Operator Safety and Public Health

The safety of the operator and others in the area can be affected by the improper design of an irrigation system. Electrical circuits must be properly designed and installed to avoid shock hazards in a wet environment. Power units and drive units must also be properly sized, mounted, aligned, and shielded to assure safe long-term operation.

Chemical injection systems must be properly designed and installed to avoid operator contact with chemicals. To ensure that systems will function safely, irrigation system components must be properly pressure-rated. Pressure relief valves and other safety equipment must be installed where required. All components must be installed according to specifications.

Improperly designed irrigation systems could pose serious public health risks. The risk is greater when irrigation systems are used for chemical and fertilizer applications in addition to irrigation. Another risk is the pollution of freshwater sources due to the backflow of chemicals and nutrients (Bayabil et al. 2020b). If the irrigation water source is a municipal or other public drinking water supply, backflow of water from an irrigation system can contaminate the water supply even if chemicals are not injected. As a result, proper design, selection, installation, and maintenance of a backflow prevention device are critical. Both Florida law and Environmental Protection Agency (EPA) regulations require that backflow prevention devices be installed on all metered systems when chemicals and fertilizer are injected into irrigation systems. Installing a backflow device is mandatory. The backflow device must always function properly. To ensure this, backflow devices need to be regularly maintained and inspected annually by

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a certified backflow technician. County or municipal codes specify the types of backflow prevention devices required to prevent the possible contamination of freshwater supplies.

Waste of Freshwater Resources

Irrigation uniformity is one aspect of a good irrigation system design. Poorly designed irrigation systems apply water nonuniformly and will result in waste of water and chemicals applied with the water. Nonuniform irrigation distribution will result in over- and/or under-irrigation of parts of fields. In such a scenario, if the irrigation manager applies a fixed amount of water across the field, plants in under-irrigated areas will suffer from moisture stress, which could lead to yield or quality reductions, while plants in over-irrigated parts of the field could show yield and/or quality reductions due to waterlogging and leaching of nutrients and chemicals. In addition, depending on the amount of excess water needed for an over-irrigated field, increased costs will be incurred for the fuel required to pump and inject excess nutrients and chemicals.

Even well-designed irrigation systems do not apply water with perfect uniformity. The cost of obtaining perfect uniformity is prohibitive. Rather, the optimum design requires that the value of the wasted natural resources be balanced by the increased cost of achieving a greater degree of irrigation uniformity, including the increased value of agricultural products needed to cover this cost.

Water Quality Deterioration

Leaching of nutrients and chemicals due to over-irrigation could result in the pollution of surface or groundwater supplies. In Florida, leaching can readily occur through the highly permeable sandy soils. It is often difficult to determine the economic and environmental costs of water pollution. This is because it is difficult to quantify the costs of pollution, and the impacts of various pollutants on the environment are often unknown. It is also impossible to eliminate the potential for water pollution because chemicals are required in the root zones and on the foliage of plants. However, the potential for water pollution can be minimized.

Proper irrigation system design and management can minimize leaching and water pollution because a well-designed and well-managed irrigation system can apply only the necessary amounts of water and chemicals. Chemigation systems, irrigation systems that are designed for chemical applications by injection with the irrigation water, have great potential for reducing water pollution from irrigated

lands (Bayabil et al. 2020a). Chemigation and fertigation systems can reduce water pollution by allowing prescription chemical and fertilizer applications, respectively. If chemicals and nutrients are applied frequently and only in the required amounts for the irrigated crop, there will be no excessive nutrient buildup in the soil that will be subject to leaching losses.

Economic Losses

Cost of Irrigation

To minimize the cost of irrigation, the designer must consider the total cost, which is the sum of the annual fixed and operating costs. The quality of design directly affects the irrigation system cost. In general, well-designed systems have greater initial costs than poorly designed systems. This occurs because larger components, including larger pipe sizes, are necessary to minimize pressure losses and achieve uniform water application. However, the operating costs of well-designed systems will usually be lower. Pumping, labor, and other operating costs will usually increase to compensate for under-designed irrigation systems. These factors will almost always make the total annual irrigation system cost greater for a poorly designed irrigation system compared to a well-designed system.

An irrigation system designer must consider existing production practices, availability of labor, and convenience to the irrigation manager. Proper consideration of these factors and manageable, efficient irrigation systems will help to minimize costs.

Plant Yield and Quality Loss

Poor irrigation system design can result in irrigation systems that cannot provide the necessary soil-water-nutrient environment for optimum crop growth. This will result in reduced yields, reduced quality, or higher costs per unit of production compared to well-designed irrigation systems.

Reduced Irrigation System Life Expectancy

The life expectancy of a poorly designed irrigation system may be much shorter than that of a well-designed system. As an example, the use of components that are not adequately pressure-rated, that are not resistant to chemicals being injected, or that are not otherwise properly installed or matched to the system, can result in early system failures.

Improper designs and installations or the failure to exercise proper caution in management can result in destructive “water hammer” forces that can damage pipes and other

components. Additionally, neglecting to consider the strengths of pipe and other component materials can result in their failures due to overburden pressures from burial, especially under roadways.

Improper selection of filtration or other water treatment equipment can result in clogging and failure of trickle irrigation systems. Likewise, insufficient consideration of the user's ability to manage and maintain filtration and water treatment equipment can result in irrigation system failure.

The selection of components not designed for use under field conditions can result in early component failure due to deterioration by solar radiation or premature weathering. Improper installation of components (e.g., exposure of PVC pipe to solar radiation, or the burial of uncoated aluminum pipe) will result in their early deterioration.

Summary

There are many possible consequences of improper irrigation system design. These include:

- Public health impacts if backflow prevention systems are not properly designed or installed
- Waste of natural resources (including water, chemicals, and the energy required for pumping) if systems are not properly designed to apply water uniformly
- Pollution of water supplies if poor system design results in nonuniform water and chemical applications and leaching of chemicals to the water supplies
- Risks to operator safety if components are not properly selected and installed
- Increased irrigation costs
- Insufficient economic return from irrigation if a poorly designed irrigation system cannot meet the crop's water requirements
- Reduced system life expectancy if components are not properly selected and installed for the operating conditions expected for each system

All of these factors must be considered when irrigation systems are designed.

References

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