Chapter 5 Irrigation Method Selection

Contents **NJ652.05**

Tables

NJ652.05 Irrigation Method Selection

(a) General

The purpose of this chapter is to provide necessary planning considerations for selecting an irrigation method and system. This chapter describes the most widely used irrigation methods and systems in New Jersey along with their adaptability and limitations. Also refer to National Engineering Handbook (NEH), Part 623, Section 15, chapters 3-9, and 11, and National Irrigation Guide, Chapter 5.

(b) Methods and Systems to Apply Irrigation Water

The four basic irrigation methods, along with the many systems to apply irrigation water, include: sprinkler, surface, micro, and subirrigation.

Sprinkler -A majority of the irrigation in New Jersey consists of the sprinkler type. This method applies water through a system of nozzles (impact and gear driven sprinkler, or spray heads) with water distributed to the sprinkler under pressure through a system of surface or buried pipelines. Sprinkler heads and nozzles are available in a wide variety of sizes, and can apply water at rates of less than 0.1 inch per hour to more than 2 inches per hour. Sprinkler irrigation systems include the following: Solid Set, Handmove Laterals, Sideroll (wheel) Laterals, Center Pivot, Linear Move, and Traveling and Stationary Guns. Low Energy Precision Application (LEPA) and Low Pressure in Canopy (LPIC) systems are included with sprinkler systems because they use center pivot and linear move irrigation systems.

Surface – This irrigation method involves the distribution of water by gravity over the soil surface either in a sheet or in furrows. Land leveling is generally required to obtain the proper soil slope for uniform water distribution.

Surface irrigation is practiced extensively in New Jersey cranberry bog management, primarily for frost control, harvesting and winter flooding. Surface irrigation has been supplemented with solid set sprinkler systems. These systems provide irrigation water for peak crop consumptive use as well as cooling and frost control. Sprinkler systems use much less water and can start operation within a few minutes, whereas it takes several hours to flood a bog for frost protection. Flooding is still used for winter-flooding to protect vines from freezing temperatures and for water-harvesting operations.

Micro – Water is applied through low-pressure, low volume discharge devices (drip emitters, line source emitters, micro spray and sprinkler heads, bubblers etc.). These are supplied by small diameter surface or buried pipe, tubing, hose or tape. There is an emitter close to the base of each plant. Water trickles or drips out the emitter and soaks into the ground. Several emitters may be placed around the base of the tree for orchard use. It is a highly efficient system, because water is applied directly to the root zone. Micro irrigation is adaptable to many specialty fruits and vegetables grown in New Jersey and is increasing in acreage each year, replacing many lower efficiency sprinkler systems such as the hand move laterals and traveling gun systems. This is resulting in a water and energy savings along with improved yield quality and quantity.

Subirrigation - Water is made available to the crop root system by upward capillary flow through the soil profile from a controlled water table. In New Jersey this is done through a system of ditches or tile drains. To be successful, the topography must be nearly level and smooth. The upper soil layers must be permeable to permit free and rapid water movement laterally and vertically. The permeable soil must be underlain by relatively impervious soil on which an artificial water table can be built up or it must have a natural high water table. Controlled drainage of muck soils has been the most common use of subsurface irrigation. Blueberries and cranberries, traditionally grown on wetland soils, are supplemented with this method of irrigation. A series of ditches and water control structures are used to maintain the water table level. If necessary, well water is also pumped into the ditches to fill and maintain the water table

during the growing season. This method is also supplemented with sprinkle and micro irrigation.

Each irrigation method and system has specific site applicability, capability, and limitations. Broad factors that should be considered are:

- crops to be grown
- topography or physical site conditions
- water supply
- climate
- energy available
- chemigation
- operation and management skills
- environmental concerns
- soils
- farming equipment
- costs

c) Site Conditions

Refer to Table 5-1 in the National Irrigation Guide, page 5-3, Site Conditions to Consider in Selecting an Irrigation Method and System.

d) Selection of Irrigation Method and System

In selecting an irrigation method and system, various factors must be considered. Primary concerns in New Jersey include available water supply, adaptability to the crops grown, cost effectiveness of the system, level of management, and labor requirements.

Table NJ 5.1, displays estimated typical life and annual maintenance for irrigation system components.

e) Adaptability and Limitations of Irrigation Methods and Systems

Sprinkler Systems

Solid Set, Permanent

- Adaptable to irregular fields and rolling terrain
- Low labor requirement
- Allows for light applications at frequent intervals
- Adaptable to irrigating blueberries, cranberries, brambles, container nursery, orchards, and trees.
- Entire system can be operated at one time for frost control and crop cooling at low application rates < 0.15”/hr.
- Easily automated
- High initial cost versus hand move laterals systems
- Wind drift and evaporation problems with low application rates < 0.15”/hr.

Solid Set, Portable

- Low labor requirement because the pipe does not have to be moved while in the field.
- Adaptable to irregular fields and rolling terrain
- Allows for light applications at frequent intervals
- Adaptable for high value crops such as vegetables, and nursery stock.
- Can be used to germinate crops that will later be drip irrigated.
- Entire system can be operated at one time for frost control and crop cooling at low application rates < 0.15”/hr.
- High initial cost of needing sufficient lateral pipe and sprinklers to cover the entire field.
- Wind drift and evaporation problems with low application rates < 0.15”/hr.
- Not easily automated.
- Efficiency is lower then permanently installed solid set due to leaky pipe connections and runoff.
- Caution must be taken during tillage and harvest operations to prevent damage to pipeline, risers and sprinkler heads.

Hand Move Lateral

- Adaptable to irrigating vegetable, orchard, berries, and potatoes
- Lowest initial cost
- Adaptable to irregular fields and rolling terrain
- Lower efficiency then solid set.
- Highest labor requirement

Side or Wheel Roll

- Adaptable to irrigating potatoes, vegetables, field crops, and alfalfa hay
- Low labor requirement
- Higher initial costs and maintenance costs then hand move laterals

- Field must be rectangular
- Not adapted to tall crops
- Topography must be flat or gently rolling

Center Pivot
- High uniformity and high efficiency with low volume and low pressure nozzles on drops.
- Adaptable for irrigating corn, potatoes, vegetables, field crops, and alfalfa hay.
- Easily automated.
- Low labor requirement
- High initial cost
- Irrigates circular area and corners with end guns or corner arms.
- High application rates at the outer end may cause runoff and erosion problems.
- Drive wheels may cause ruts in some soils.
- Requires uniform topography with slopes <10%

Linear Move
- Adaptable for irrigating corn, potatoes, vegetables, field crops, and alfalfa hay.
- Easily automated
- Can irrigate an entire field
- Uniform water application
- Requires rectangular fields
- Higher labor then a center pivot but less then a hand move system.
- Requires uniform topography with slopes <10%.

Traveling Gun
- Adaptable for irrigating corn, potatoes, vegetables, alfalfa and field crops.
- Adaptable to irregular shaped fields.
- Moderate costs
- Less labor then hand move laterals
- Require high operating pressures and high power pumping units.
- Towpaths are required in the crop.
- Wind seriously affects the distribution pattern, causing non-cropped areas to be wetted.
- Low efficiency due to high evaporation and runoff potential.

Microirrigation
- Highest potential application efficiency-low runoff and evaporation losses.
- Highest design distribution uniformity.
- Spoon feeding directly to root zone.
- High yields and excellent quality.
- Low water use enables small water supplies to be utilized.
- Requires 50% of the water needed for an overhead system.
- Low pumping costs due to low pressure and flow requirements
- Pipe network can be smaller then high pressure/flow systems and therefore less costly.
- Disease control is high since leaves are not wetted.
- Ability to fertigate through system resulting in less fertilizer applied.
- Extensive automation is possible.
- Field operations can continue while irrigating.
- Adaptable to irregular shaped fields.
- Entire system can be operated at one time.
- High degree of filtration and pressure regulation required.
- High maintenance required and management skills.
- Requires good quality water supply and properly designed filtration system to prevent emitter clogging.
- May require water treatment through chlorination to kill algae, bacteria, or precipitate iron out of water supply.
- Rodent and insect damage to plastic tape/hose can be a problem.
- Not adaptable to frost protection.
- Initial investment and annual costs are higher than some other methods.

Point Source Drip Emitter
- Adaptable for irrigating orchards, berries, and vineyards
- With pressure compensation can be operated on undulating topography and odd shaped fields.
- Application uniformity not affected by wind.

Line Source Tape

- Best adaptable to irrigating fresh vegetables and row crops.
- Application uniformity not affected by wind.
- Not suitable on steep or undulating topography.

Micro Spray/Sprinkler

- Adaptable for irrigating orchards, nursery trees and container stock.
- Provides frost control in orchards with new applications in vineyard and small fruit.
- Application uniformity can be affected by wind.
- Higher evaporation losses.

Subsurface Irrigation

Open Ditches with Control Structures

- In NJ mostly adapted to blueberry and cranberry production.
- Topography must be level or slopes very gentle and uniform.
- Adaptable to soils with low available water holding capacity and high intake rates.
- Soil must have either a natural high water table or impermeable layer in the substratum.

Tables NJ 5.2 – NJ 5.5 display factors that affect the adaptation and operation of various irrigation methods and systems. In these tables, + indicates positive effects or preferred selection, the – indicates negative effects or provides possible reasons for not choosing this alternative (another system or method should be considered, and 0 indicates neutral effect or should provide no influence on selection.

Table NJ 5.6 gives recommended slope limitations for sprinkler systems.

Table NJ 5.1 Typical life and annual maintenance cost percentage for irrigation systems components

System and components	Life (yr)	Annual maint. (% of cost)	System and components	Life (yr)	Annual maint. (% of cost)
Sprinkler systems	10 - 15	2 - 6	**Surface & subsurface systems**	15	5
Handmove	15 +	2			
Side or wheel roll	15 +	2	Related components		
End tow	10 +	3	Pipelines		
Side move w/drag lines	15 +	4	Burled thermoplastic	25 +	1
Stationary gun type	15 +	2	Buried steel	25	1
Center pivot-standard	15 +	5	Surface aluminum	20 +	2
Linear move	15 +	6	Surface thermoplastic	5 +	4
Cable tow	10 +	6	Hurled nonreinforced concrete	25 +	1
Hose pull	15 +	6	Buried galv. steel	25 +	1
Traveling gun type	10 +	6	Buried corrugated metal	25 +	1
Fixed or solid set			Buried reinforced PMP	25 +	1
Permanent	20 +	1	Gated pipe, rigid, surface	10 +	2
Portable	15 +	2	Surge valves	10 +	6
Sprinkler gear driven, impact & spray heads	5 - 10	6	Pumps		
Valves	10 - 25	3	pump only	15 +	3
			w/electric motors	10 +	3
Micro systems [1/]	1 - 20	2 - 10	w/internal combustion engine	10 +	6
Drip	5 - 10	3			
Spray	5 - 10	3	Wells	25 +	1
Bubbler	15 +	2	Linings		
Send-rigid, hurled	10 - 20	2	Nonreinforced concrete	15 +	5
Semi-rigid, surface	10	2	Flexible membrane	10	5
Flexible, thin wall, buried	10	2	Reinforced concrete	20 +	1
Flexible, thin wall, surface	1 - 5	10			
Emitters & heads	5 - 10	6	Land grading, leveling[2/]		
Filters, injectors, valves	10 +	7	Reservoirs[3/]		

1/ With no disturbance from tillage and harvest equipment.
2/ Indefinite with adequate maintenance.
3/ Indefinite with adequate maintenance of structures, watershed.

Table NJ 5.2 Factors affecting the selection of periodic move, fixed, or solid set sprinkler irrigation systems

Item	----Periodic move----			----Solid set or fixed----		
	sideroll	hand	gun	perm	port	gun
Crop						
Field—close growing	0	0	0	0	0	0
Field—row	0	0	0	-	0	-
Vegetable—fresh	0	0	0	0	0	0
Vegetable—seed	-	-	-	-	-	-
Orchards, berries, grapes	-	0	-	+	+	-
Alfalfa hay	0	0	0	-	-	-
Corn	-	-	0	-	-	0
Cotton	-	-	-	-	-	-
Potatoes, sugar beets	0	0	0	-	0	-
Land & soil						
Low AWC	0	0	0	+	+	+
Low infiltration rate	0	0	-	0	0	-
Mod- infiltration rate	0	0	0	0	0	0
High infiltration rate	0	0	0	+	+	+
Variable infiltration rate	+	+	+	+	+	+
High salinity or sodicity	-	-	-	-	-	-
Highly credible	+	+	-	+	+	-
Steep & undulating Togo	-	+	-	0	0	-
Odd shaped fields	-	0	+	+	+	+
Obstructions [1/]	-	0	0	-	0	0
Stony, cobbly	0	0	0	0	0	0
Water supply						
Low cont. flow	+	+	+	+	+	+
High intermit, flow	-	-	-	-	-	-
High salinity or sodicity	-	-	-	-	-	-
High sed. content	-	-	-	-	-	-
Delivery schedule						
continuous	+	+	+	+	+	+
rotation	-	-	-	-	-	-
arranged, flexible	0	0	0	0	0	0
demand	0	0	0	0	0	0
Climate						
High rainfall	+	+	+	+	+	+
Low rainfall—arid	0	0	0	0	0	0
Windy	-	-	-	-	-	-
High temp—humid	+	+	+	+	+	+
High temp—arid	-	-	-	-	-	-
Social/institutional						
Automation potential	-	-	-	+	+	0
Easy to manage	0	0	0	+	+	+

1/ Obstructions may include roads, buildings, rock piles, trees, above and below ground utilities, and oil pipelines.

Table NJ 5.3 Factors affecting the selection of continuous/self moving[1/] sprinkler irrigation systems

Item	----LEPA[2/]----		----LPIC[3/]----		--Center pivot--		----Linear----		
	Center pivot	linear	Center pivot	linear	high press	low press	high press	low press	gun
Crop									
Field-close growing	-	-	-	-	0	0	0	0	0
Field-row	0	0	0	0	0	0	0	0	0
Vegetable-fresh	0	0	0	0	0	0	0	0	0
Vegetable-seed	0	0	0	0		-		-	-
Orchard, berries, grapes	-	-	-	-	-	-	-	-	-
Alfalfa hay	-	-	-	-	0	+	0	+	0
Corn	0	0	0	0	0	0	0	0	0
Cotton	0	0	0	0	-	-	-	-	-
Potatoes, sugar beets	0	0	0	0	0	0	0	0	0
Land & soil									
L0wAWC	+	+	+	+	+	+	+	+	0
Low infiltration rate	0	0	-	-	-	-	-	-	-
Mod. infiltration rate	0	0	0	0	-	-	0	0	0
High infiltration rate	+	+	+	+	+	+	+	+	+
Variable infiltration rate	+	+	+	+	+	+	+	+	+
High salinity and sodicity	0	0	0	0	0	0	0	0	0
High erodible	0	0	0	0	-	-	-	-	-
Steep & undulating topog	-	-	-	-	-	-	-	-	+
Odd shaped fields	-	-	-	-	-	-	-	-	+
Obstructions[4/]	-	-	-	-	-	-	-	-	+
Stony, cobbly	0	0	0	0	0	0	0	0	0
Water supply									
Low cont. flow rate	+	+	+	+	+	+	+	+	+
High intermit. flow rate	-	-	-	-	-	-	-	-	-
High salinity	-	-	-	-	-	-	-	-	-
High sed. content	-	-	-	-	-	-	-	-	-
Delivery schedule									
continuous	+	+	+	+	+	+	+	+	+
rotation	-	-	-	-	-	-	-	-	-
Arranged, flexible	0	0	0	0	0	0	0	0	0
demand	0	0	0	0	0	0	0	0	0
Climate									
Humid & subhumid	+	+	+	+	+	+	+	+	+
Arid & semiarid	0	0	0	0	0	0	0	0	0
Windy	+	+	+	+	-	-	0	0	-
High temp-humid	+	+	+	+	+	+	+	+	+
High temp-arid	0	0	0	0	0	0	0	0	0
Social/institutional									
Automation potential	+	-	+	-	+	0	-	-	-
Easy to manage	0	0	0	0	0	0	0	0	0

1/ Continuous/self moving describes a sprinkler system that is self moving in continuous or star-stop operations.
2/ LEPA-Low Energy Precision Application system (in-canopy with good soil and water management).
3/ LPIC-Low Pressure In Canopy system.
4/ Obstructions may include roads, buildings, rock piles, trees, and aboveground utilities.

Table NJ 5.4 Factors affecting the selection of micro irrigation systems [1/]

Item	Point source drip emitter	Line source cont. tube	Micro spray/ sprinkler	Basin bubbler
Crop				
Field—close growing	-	-	-	-
Field row	-	0	-	-
Vegetable fresh	-	+	-	-
Vegetable seed	-	0	-	-
Orchards, berries, grapes	+	-	+	+
Alfalfa hay	-	-	-	-
Corn	-	0	-	-
Cotton	-	+	-	-
Potatoes, sugar beets	-	0	-	-
Land & soil				
LowAWC	+	+	+	+
Low infiltration rate	0	0	0	0
Mod. infiltration rate	0	0	0	0
High infiltration rate	+	+	+	0
Variable infiltration rate	+	+	+	+
High salinity and sodicity	0	+	+	0
Highly erodible	+	+	+	0
Steep & undulating topog	+	-	+	-
Odd shaped fields	+	+	+	+
Obstructions[2/]	+	+	+	+
Stony, cobbly	+	+	+	+
Water supply				
Low cont. flow rate	+	+	+	+
High intermit. flow rate	-	-	-	-
High salinity	-	-	-	-
High sed. content	-	-	-	-
Delivery schedule				
continuous	+	+	+	+
rotation	-	-	-	-
arranged, flexible	0	0	0	0
demand	0	0	0	0
Climate				
Humid & subhurnid	0	0	0	0
Arid & semiarid	0	0	0	0
Windy	+	+	-	0
High temp—humid	0	0	0	0
High temp arid	0	0	0	0
Social/institutional				
Easy to manage	-	-	-	-
Automation potential	+	+	+	+

1/ Not suitable unless water supply is non-saline, low SAR, and very high quality.
2/ Obstructions may include roads, buildings, rock piles, trees, and below-ground utilities.

Table NJ 5.5 Factors affecting the selection of subirrigation systems[1/]

Item	Water table control	Item	Water table control
Crop		**Water supply**	
Field - close growing	0	Low cont. flow rate	+
Field - row	0	High intermit flow rate	-
Vegetable - fresh	0	High salinity	-
Vegetable - seed	0	High sed. content	-
Orchards, berries, grapes	0		
Alfalfa hay	-	**Delivery schedule**	
Corn	0	continuous	+
Cotton	-	rotation	-
Potatoes, sugar beets	0	arranged, flexible	-
		demand	0
Land & soil			
Low AWC	0	**Climate**	
Low permeability	0	High rainfall	+
Mod. permeability	+	Low rainfall - arid	-
High permeability	0	Windy	+
Variable infiltration rate	0	High temp - humid	+
High salinity and sodicity	-	High temp - arid	+
Highly erodible	0		
Undulating topography	-	**Social & institutional**	
Odd shaped fields	0	Easy to manage	0
Obstructions [2/]	0	Automation potential	0
Stony, cobbly	-		

1/ Not suitable unless water supply is nonsaline, low salt, and very high quality.
2/ Obstructions may include roads, buildings, rock piles, trees, and belowground utilities.

Table NJ 5.6 Slope limitations for sprinkler irrigation systems

Type	Maximum slope (%)[1/]	Comments
Periodic move/set		Laterals should be laid cross slope to minimize and control pressure variation. Consider using pressure or flow control regulators in the mainline, lateral, or individual sprinkler spray heads, when pressure differential causes an increase of > 20 % of design operating pressure.
portable handmove	20+/-	
sideroll - wheel mounted	10	
gun type	20+/-	
end tow	5-10	
Fixed (solid) set		
permanent laterals	no limit	
portable laterals	no limit	
gun type	no-limit	
Continuous move		
center pivot	15	
linear move	15	
gun type	20+/-	
LEPA		
center pivot	1.0	
linear	1.0	
LPIC		
center pivot	2.5	
linear	2.5	

1/ Regardless of type of sprinkler irrigation system used, runoff and resulting soil erosion becomes more hazardous on steeper slopes. Proper conservation measures should be used; i.e., conservation tillage, crop residue use, filter strips, pitting, damming-diking, terraces, or permanent vegetation.