Planning and Economics of Forage Irrigation

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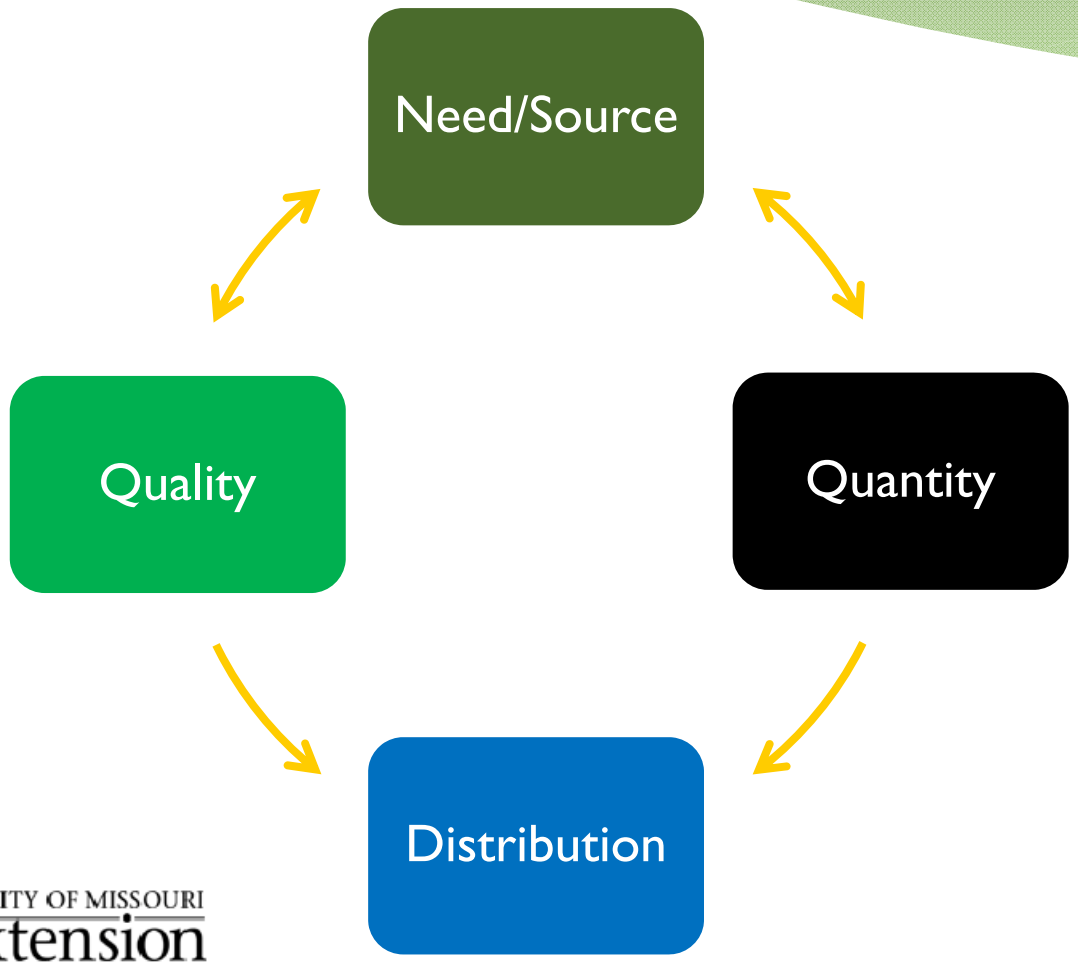
Total Water System Overview



No direct path from need/source to distribution.

Total Water System Overview

Water Need and Source

What is the quantity and quality of water by use and where are possible sources?

Water Quantity

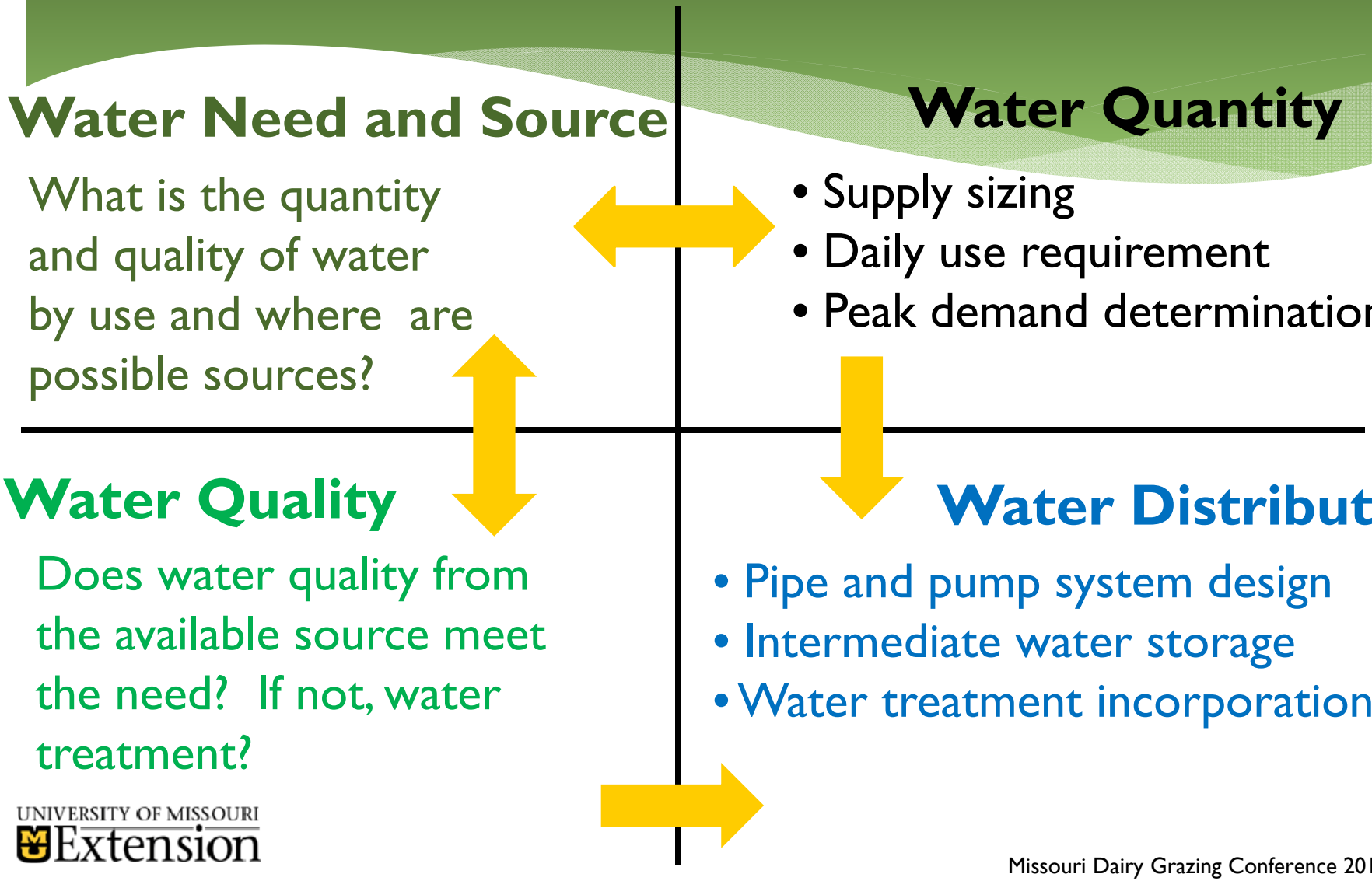
- Supply sizing
- Daily use requirement
- Peak demand determination

Water Quality

Does water quality from the available source meet the need? If not, water treatment?

Water Distribution

- Pipe and pump system design
- Intermediate water storage
- Water treatment incorporation



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Water Need

* Daily water need for dairy herd, equipment cleaning and cooling.
* Estimate peak water demand and simultaneous use.
  * Water flow rate for drinking water
  * Water flow rate for washing equipment
  * Water flow rate for sprinkler cooling
* Water desired for pasture irrigation.

Primary Water Uses and Quantities for Dairy Operations

	Drinking Water (gallons/head/day)	Supplemental Cooling Water (gallons/head/day)	Parlor Wash Water (gallons/cow/day)
Calves	6 to 10		
Heifers	10 to 15		
Dry Cows	20 to 30	8 to 12	
Milk Cows	35 to 50	10 to 15	10 to 50

Irrigation Water – about 27,200 gallons per acre-inch of water {acre-inch = 1 inch of water applied on 1 acre of pasture}

Water Quantity - General

* Estimate daily water need based on use values.
* Estimate peak water need based on use values and behavior of animals.
  * Single animal water drinking rate
  * Number of animals drinking at one time
  * Additional water uses when animals are drinking
  * Irrigation water demand

Potential Water Sources

* Ground water accessed by using well
* Surface water impoundment
* Streams and rivers
* Public water

* Missouri major water users (100,000 gallons per day {70 gpm}) – should register water use annually with Missouri Department of Natural Resources.

Water Source - Wells

* Determine if well can deliver daily demand.
* If daily demand not met, additional wells or water sources must be located or size of operation downsized.
* Can well supply peak water use demand?
* If peak demand not met, intermediate water storage and booster pump is required.

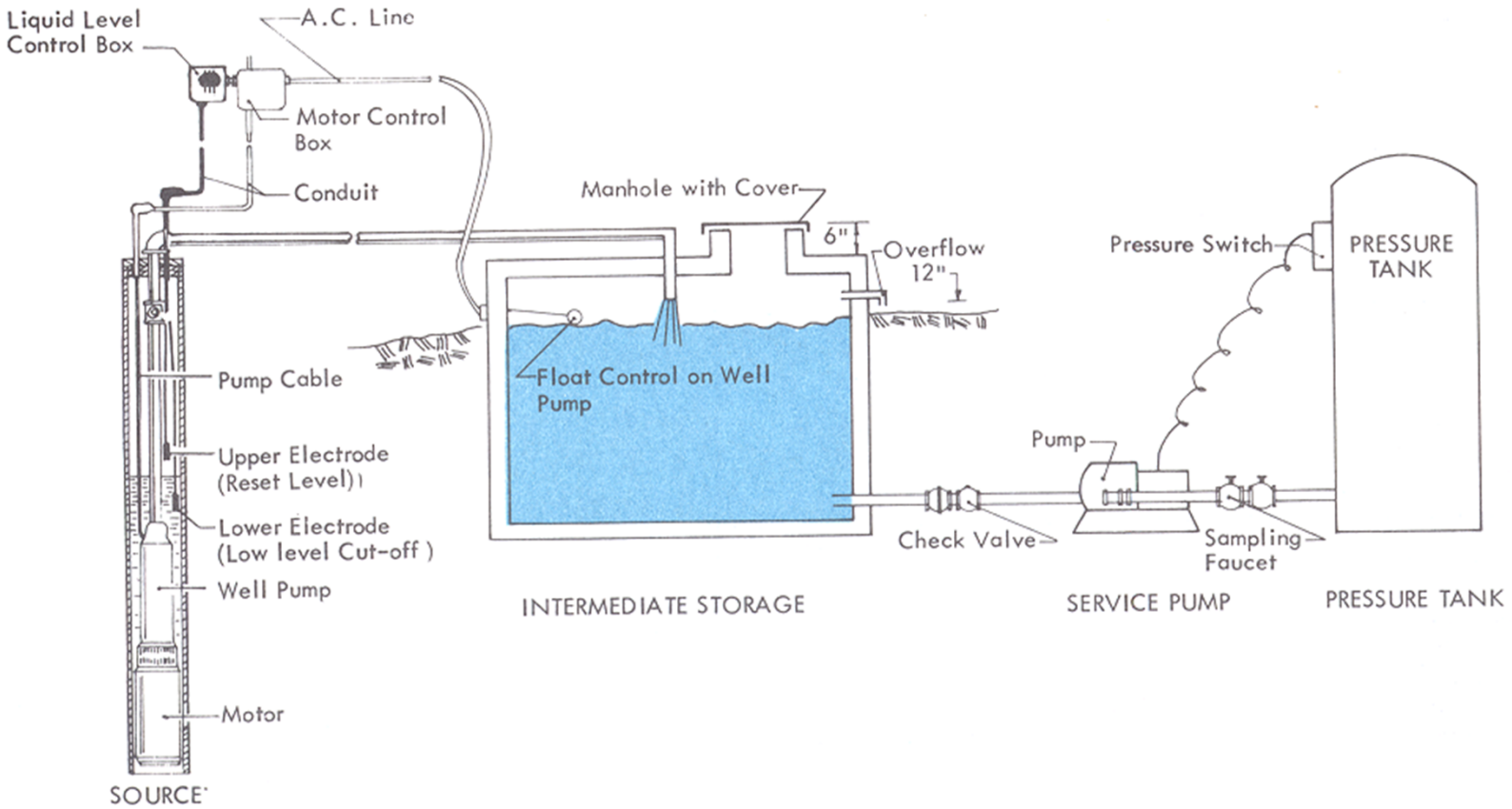
Well System Capacity

* Well system capacity needs to be large enough to supply daily water need in 10 to 12 hours. Some designers assume 5 to 8 hours to supply daily need.
* Maximum pump size needs to be slightly smaller than maximum well yield capability.
* Can a well system be constructed to meet water need for location?

Well Water Delivery

* If well can supply peak water need, pump in well supplies water to operation.
* If well can deliver daily need but not meet peak demand, then an intermediate water storage system needs to be designed and installed.
* If well system can not provide daily need, re-evaluate operation's goals or find additional water supply capability.

Intermediate Storage



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Water Source - Impoundments

* Size pump and pipe system to supply peak demand.
* Water impoundment should be large enough to store at least one year and better - two year water supply.
* Ensure watershed area draining runoff is large enough to refill impoundment within a normal year.
* Are other surface water sources needed to refill impoundment?

Estimating Surface Water Storage Requirements in Missouri

1. Estimate daily water usage in gallons per day
2. Annual estimated water usage = Step 1 * 365
3. Annual acre-feet usage = Step 2 divided by 325,828.8
4. For two year supply → multiply step 3 by 4 (2 year supply and 50% loss)
5. Estimate watershed area → multiply step 4 by 2.4 to get watershed area to refill pond in one average year

Water Source – Rivers & Streams In Missouri

* Ensure that you have ownership of land connected to the water source where pump is to be located.
* Estimate volume of water to be pumped each year.
* Consider pumping to an intermediate storage impoundment – especially for low flow sources.
* Best to use a floating intake (minimize stream bank and channel impacts).
* Do not adversely impact a downstream owner or downstream fish habitat.

Water Source – Public Supplies

* Do not assume water for dairy operation can come from public water system.
* Experience has indicated any one of the following responses can be given to a prospective dairy operation.
  1. Connect and use as much as desired (not typical)
  2. Connect and use a limited amount or for emergency purposes only (typical response)
  3. Do not connect (a more common response for systems having trouble meeting current demand for water)

Important Point

No water supply, don't bother with irrigation!

Factors When Choosing an Irrigation System

* Amount of water available
* Shape, slope and soil type of the land
* Energy cost and availability
* Labor considerations
* Irrigation system cost and return

Forage Response

* Rapid growth stages for forages represent times of the year when one can achieve the most forage yield improvement from irrigation if rainfall is inadequate.
* Note that for cool-season species, that rainfall is often adequate when temperatures are ideal for growth.

Missouri guidelines for irrigation forage response

Species	lbs. D.M./acre-inch water *
Cool season perennial grass	450 to 700
Warm season grass	600 to 1,000

* Response is based on effective water available for plant growth. Soil water holding capacity, growth conditions and application efficiency should be a part of any irrigation planning program.

Pod-Line Irrigation System
(Low Pressure)

* Series of pod sprinklers on a drag hose
* Each pod irrigates 50 ft. x 50 ft.
* Advantages:
  * Flexibility
  * Low capital investment
* Disadvantages:
  * Small acreage (~ 10 acres per line)
  * Manual move system

Traveling Irrigator
(Low Pressure)

* Wheeled system
* Sprays water in a spinning motion
* Advantages:
  * Flexibility
  * Low pressure (20-50 psi)
* Disadvantages:
  * Labor intensive, reset system after each run

Traveling Gun
(High Pressure)

* Large sprinkler gun on a wheeled cart and a reel system
* Advantages:
  * Flexibility
  * Cover larger acreage (80-100 ac.)
* Disadvantages:
  * High energy requirements
  * Labor intensive, reset system after each path

Center Pivot

(Low or High Pressure)

* Series of sprinklers on a self-propelled system that rotates around a pivot point
* Advantages:
  * Easy to operate / low labor needs
  * Towers can be added/subtracted to accommodate field size
  * Can spread effluent or cool cows
* Disadvantages:
  * Not all fields are conducive (irregular field or high slopes)
  * High capital investment

Economics

* Should be carefully considered when investing in a forage irrigation system.
* Understand the other alternatives for drought risk mitigation.
  * Investing in additional storage for harvested forages and carrying additional hay or silage inventory
  * Weather insurance (such as PRF or TWI)
* Irrigation costs to consider:
  * Ownership
  * Operating

Ownership Costs

* Depreciation on capital investments (equipment, piping, pumps, storage)
  * *(Purchase price – salvage value) / useful life*
* Interest on the capital investments
  * *(Purchase price + salvage value, divided by 2) x annual interest rate*
* Property taxes
  * *Assessed value (12% on farm equipment) x local tax rate*
* Insurance
  * Vary by insurance carrier and policy chosen

Operating Costs

* Power (pumping)
  * Varies by fuel price, operating pressure, pumping lift and volume of water applied
* Labor (setup and operation)
  * Labor rate (wages, SS, Medicare, etc.) x labor hours
* Equipment repair / maintenance
  * Vary by component, its usage and age of life
  * Tend to run from one to five percent per year of average investment (purchase price + salvage value, divided by 2)

Pod-line Irrigation Example

Water volume applied:
2,715,400 gallons/year

Water source: nearby river, lake or lagoon

Additional dry matter expected from irrigation:
30 tons/year

Capital investments:

* Pod-line system (12 pods with tubing) - $3,000
* Source pump and power unit (35 gpm) - $1,000
* Distribution pipe, connections, intake - $1,500

Pod-line irrigation (10 acres, 10 acre-inches per year)

	Assumptions	Annual Cost	Per Acre
Ownership costs:			
Depreciation	15 years of useful life	$366.67	$36.67
Interest	5% of avg. investment	$137.50	$13.75
Taxes	0.25% of avg. investment	$6.88	$0.69
Insurance	0.50% of avg. investment	$13.75	$1.38
	Total ownership costs	$524.79	$52.48
Operating costs:			
Labor	6 hrs./irrigation @ $10/hr.	$600.00	$60.00
Repair	3% of avg. investment	$82.50	$8.25
Power	Electric @ $0.11/kWh, 2.3 hp	$245.14	$24.51
	Total operating costs	$927.64	$92.76
	Total annual costs	$1,452.44	$145.24
Irrigation cost per dry matter ton produced			$48.41 dollars/ton

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Traveling Irrigator Example

Water volume applied: 12,219,300 gallons/year

Water source: nearby river, lake or lagoon

Additional dry matter expected from irrigation: 135 tons/year

Capital investments:

* Traveling irrigator - $6,000
* Source pump and power unit (120 gpm) - $2,250
* Distribution pipe, connections and intake - $3,000

Traveling irrigator irrigation (30 acres, 15 acre-inches per year)

	Assumptions	Annual Cost	Per Acre
Ownership costs:			
Depreciation	15 years of useful life	$750.00	$25.00
Interest	5% of avg. investment	$281.25	$9.38
Taxes	0.25% of avg. investment	$14.06	$0.47
Insurance	0.50% of avg. investment	$28.13	$0.94
	Total ownership costs	$1,073.44	$35.78
Operating costs:			
Labor	9 hrs./irrigation @ $10/hr.	$900.00	$30.00
Repair	3% of avg. investment	$168.75	$5.63
Power	Electric @ $0.11/kWh, 7.8 hp	$1,103.15	$36.77
	Total operating costs	$2,171.90	$72.40
	Total annual costs	$3,245.34	$108.18
Irrigation cost per dry matter ton produced			$24.04 dollars/ton

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Traveling Gun Example

Water volume applied: 24,438,600 gallons/year

Water source: nearby river, lake or lagoon

Additional dry matter expected from irrigation: 270 tons/year

Capital investments:

* Traveling gun and cart - $30,000
* Source pump and power unit (350 gpm) - $17,500
* Distribution pipe, connections and intake - $5,000

Traveling gun irrigation (60 acres, 15 acre-inches per year)

	Assumptions	Annual Cost	Per Acre
Ownership costs:			
Depreciation	15 years of useful life	$3,500.00	$58.33
Interest	5% of avg. investment	$1,312.50	$21.88
Taxes	0.25% of avg. investment	$65.63	$1.09
Insurance	0.50% of avg. investment	$131.25	$2.19
	Total ownership costs	$5,009.38	$83.49
Operating costs:			
Labor	18 hrs./irrigation @ $10/hr.	$1,800.00	$30.00
Repair	3% of avg. investment	$787.50	$13.13
Power	Electric @ $0.11/kWh, 34.6 hp	$3,364.98	$56.08
	Total operating costs	$5,952.48	$99.21
	Total annual costs	$10,961.86	$182.70
Irrigation cost per dry matter ton produced			$40.60 dollars/ton

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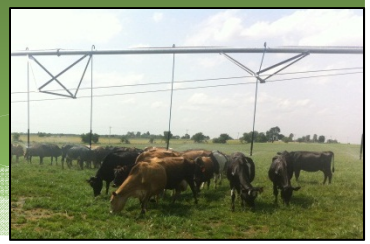
Center Pivot Example



Water volume applied: 54,579,540 gallons/year

Water source: Well

Additional dry matter expected from irrigation: 603 tons/year

Capital investments:

* Pivot machine, electric generator and concrete pad - $77,000
* Source pump and power unit (780 gpm) - $28,000
* Well (500 foot) - $11,000
* Fuel tank - $1,100

Center pivot irrigation (134 acres, 15 acre-inches per year)

	Assumptions	Annual Cost	Per Acre
Ownership costs:			
Depreciation	25 years of useful life	$4,684.00	$34.96
Interest	5% of avg. investment	$2,927.50	$21.85
Taxes	0.25% of avg. investment	$146.38	$1.09
Insurance	0.50% of avg. investment	$292.75	$2.18
	Total ownership costs	$8,050.63	$60.08
Operating costs:			
Labor	6.7 hrs./irrigation @ $10/hr.	$670.00	$5.00
Repair	4% of avg. investment	$2,342.00	$17.48
Power	Diesel @ $3.50/gal., 179 hp	$32,203.61	$240.33
	Total operating costs	$35,215.61	$262.80
	Total annual costs	$43,266.24	$322.88
Irrigation cost per dry matter ton produced			$71.75 dollars/ton

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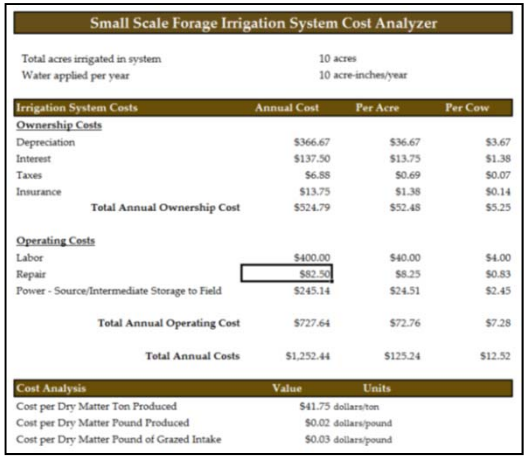
Note: Using electricity as power source will lower irrigation annual costs to **$28,447** or **$47.18** per DM ton produced

Decision Tool

* A spreadsheet tool was developed for producers to estimate the cost of using irrigation on forage systems.
* Users detail an irrigation system based on water application, pumping rate, capital investments, and cost assumptions.
  * Total annual costs
  * Cost per dry matter ton, lb. or grazed intake
* Spreadsheet downloaded at http://crops.missouri.edu/irrigation/decisiontool.xlsx



Small Scale Forage Irrigation System Cost Analyzer

Total acres irrigated in system	10 acres
Water applied per year	10 acre-inches/year

Irrigation System Costs	Annual Cost	Per Acre	Per Cow
Ownership Costs			
Depreciation	$366.67	$36.67	$3.67
Interest	$137.50	$13.75	$1.38
Taxes	$6.88	$0.69	$0.07
Insurance	$13.75	$1.38	$0.14
Total Annual Ownership Cost	$524.79	$52.48	$5.25
Operating Costs			
Labor	$400.00	$40.00	$4.00
Repair	$82.50	$8.25	$0.83
Power - Source/Intermediate Storage to Field	$245.14	$24.51	$2.45
Total Annual Operating Cost	$727.64	$72.76	$7.28
Total Annual Costs	$1,252.44	$125.24	$12.52

Cost Analysis	Value	Units
Cost per Dry Matter Ton Produced	$41.75	dollars/ton
Cost per Dry Matter Pound Produced	$0.02	dollars/pound
Cost per Dry Matter Pound of Grazed Intake	$0.03	dollars/pound

Questions?