ENVIRONMENTAL QUALITY

MU Guide

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Pumps and Watering Systems for Managed Beef Grazing

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Water for beef cattle may come from wells, ponds, creeks, springs or public water supplies, although the last of these sources can be too costly for watering a large herd year-round. Wells are a prime source of water at the farmstead. However, cattle on pasture are usually watered from surface sources in Missouri. Keeping the animals from entering the water source will generally maintain higher water quality and result in better livestock production. A study in Oregon showed that placing a water trough 100 meters from a stream under winter (hay) feeding conditions reduced the amount of time that cattle spent in the stream by 90 percent. A springtime evaluation of water gap designs showed that water gaps (access to stream) three and six feet wide eliminated fecal deposition into the stream. A study in Virginia showed that, when given a choice, cattle drank from a water trough 92 percent of the time rather than from a stream, with a 77 percent reduction in stream bank erosion. Concentrations of total suspended solids, total nitrogen and total phosphorous decreased by 90, 54 and 81 percent, respectively, when an alternate water source was provided. Similar reductions were observed in concentrations of fecal coliforms and fecal streptococci.

Having waterers strategically located is important for achieving maximum use of a pasture in a managed grazing system and for keeping the ground covered with vegetation to prevent erosion (Figure 1). Ideally, a waterer might be placed in the center of each paddock; practically, the cattle should not have to walk more than 700 to 900 feet to water. Having to walk down a lane to a central watering point may decrease beef production, lead to erosion in the lane, and result in about 15 percent of the manure being deposited in the lane.

Supplying water to each paddock may require a major investment in pumps, piping and tanks. To maintain the highest water quality, unlimited access to streams should be evaluated. In some situations, it may be desirable to limit stream access for drinking and to protect the access points by hard surfacing. An alternative is to fence off the streams and pump water to tanks.

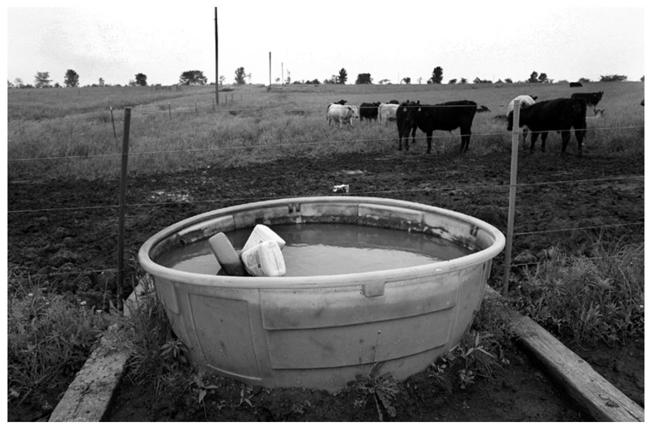

Figure 1. The majority of beef cattle are managed in pasture systems that depend on convenient waterers at several locations on the farm for maximum production efficiency.

To promote proper grazing management, management-intensive grazing (MiG) systems may be cost-shared by funds from the Missouri sales tax for soil conservation and parks as a water quality enhancement practice. Cost sharing is available under the DSP-3 Practice (Planned Grazing System) for various components used for fencing and watering livestock. Contact your local Soil and Water Conservation District/NRCS office for details.

Water quality

Calves need better quality water than cows, and they won't fight mud or cows to get it. Cows may wade out into a pond or stream to get better water, but calves tend to drink the water they can reach from the shore. Increases of 50 pounds per head in weaning weight have been reported when water in sufficient quantity and quality is provided. A "drinking creep" for calves may be beneficial if the watering system for the cows is marginal. Waterborne diseases include leptospirosis, foot rot, red nose, bovine virus diarrhea (BVD), TB and mastitis.

Water quantity

The first step in designing a water distribution system for livestock is to determine the water demand

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on a herd basis and on a time basis. Sizing components such as pumps, pipes, flow valves and drinking reservoirs (tanks) to the herd demand is critical for a smoothly operating grazing system.

The daily water requirement for cattle varies with their size and age, activity, lactation, and dry matter intake, with the moisture content of feed and forage, and with air temperature and distance to water. Lush forage may have a moisture content of 70 to 90 percent and supply a major portion of the required water in cool weather. Lactating cows will consume much higher amounts of water than will nonlactating cows, the increased water consumption being almost directly proportional to the level of milk production. The water requirement for a 1,000-pound cow is about 10 gallons/day when the air temperature is 40 degrees F and about 27 gallons/day at 90 degrees F. When temperatures rise from 70 to 95 degrees, an animal's water requirement can increase 2.5 times. The Missouri NRCS has defined the peak demand for watering livestock as 30 gallons per day (at 90 degrees) per 1,000 pounds live weight. The water requirement is related to forage intake; as forage intake increases, so does the water requirement. Mature beef cows will consume only about 3 to 5 pounds of water per pounds of dry matter intake while calves will consume 5 to 7 pounds of water per pound of dry matter. Cattle prefer water at about 90–95 degrees F.

Table 1 illustrates the relationship between increasing air temperature and the water intake of dairy heifers.

Table 1. Intake of total digestible nutrients (TDN) and drinking water by yearling dairy heifers under various temperature conditions.

Air temperature	lb TDN/ day	lb water/ lb TDN	gal water/ day
35	10.3	4.7	6.0
50	9.2	5.2	6.0
70	9.2	7.2	8.0
80	8.8	9.0	9.5
90	6.6	22.2	17.6
95	6.4	24.8	19.0

Table 2 lists estimated winter and summer water consumption by various categories of cattle.

Table 2. Estimated water consumption by various categories of cattle.

Livestock	Winter gallons/day	Summer gallons/day
Cow/calf/ pairs	13	30–35
Dry cows	10	30
Calves		
(1½ gal/day per 100 # body wt.)*	6	12
Growing cattle, 400–800 lb	8	12–24
Bred heifers (800 lb)	9	24
Bulls	14	30–40

Distribution systems for individual paddocks

In most cases, pumping water through a system of pipes and valves is required to provide water for all paddocks or pasture subdivisions. Such a distribution system also requires a pump (or elevated water reservoir) that can develop sufficient pressure to push water through several hundred feet of piping and perhaps several elbows, junctions, and valves, to a tank that may be at an elevation many feet above the water supply, at a rate sufficient to satisfy the thirst of the animals.

Pipe and pipelines

Pipe used in MiG systems is usually made of plastic. The pipe is either laid on the surface for portable systems or buried for fixed systems and systems for cold weather operation. In Missouri, frost depth ranges from 15 inches below the surface at New Madrid to 40 inches on the Iowa line. Wet, compacted soil that is exposed (no snow cover) may freeze 2 feet deeper than the depths above. Some supply companies have developed new, more durable aboveground piping systems and quick coupler hydrants that reduce but do not eliminate the potential for winter freeze and rupture. Freeze-resistant pipe allows expansion of the pipe during periods of cold weather. However, other components of the pipeline, such as float valves and connectors, may not be freeze proof. Valves or unions can be installed at low points so that the pipeline can be drained as needed. Drainage should be provided on aboveground installations. Install valves at various locations on pipelines to facilitate repair of broken appurtenances and damaged pipe.

Plastic pipe should meet the requirements specified in ASTM D 2239 or D 3035 for polyethylene (PE) and D 1785 or D2241 for polyvinyl chloride (PVC) pipe. Flexible black or white PE pipe is available in 100-ft coils. Common sizes range from ¾- to 2-inch nominal inside diameters. Pipes less than 1-inch diameter are seldom recommended, and 1½-inch diameter pipe should be considered for distances more than ¼ mile. One-inch black plastic pipe costs approximately 25 cents per foot, and 1½-inch pipe is about 50 cents per foot. The cost of trenched-in plastic waterline is approximately $1.00 to $1.50 per foot. Refer to Table 3 as a guide for plastic pipe selection to keep friction losses in the pipeline within a reasonable range.

Always use pressure-rated piping, and select UV-stabilized pipe for use above ground. White pipe will stay cooler above ground than black pipe, but it costs approximately twice as much. If waterlines are placed in the fencerow, they will be less susceptible to livestock damage and will be quickly shaded by vegetation. Vegetation will help to protect the pipe from the sun and to keep the water cooler. Where fire (controlled burning) is to be used as a management tool, provisions must be made to protect plastic pipe from fire. Shallow burial (where soils are suitable) may be advised to protect pipe from fire.

Galvanized steel pipe is occasionally used for special installations where high strength is required. Steel pipe should meet the requirements specified in ASTM A 53 or in AWWA Specification C 202. Caution: Steel pipe connected to standard copper or brass fittings may corrode rapidly.

Gravity and low-pressure systems: NRCS Practice Standards define low-pressure systems as having pressures less than 15 psi, pipe runs less than 1,500 feet, and ¾-inch minimum pipe size. Low-pressure pumping systems using nose pumps, solar pumps, etc., will be considered gravity systems if pressure does not exceed 15 psi. Use a UV-resistant (2% carbon black), linear low-density polyethylene pipe with 100 psi minimum rating for gravity flow (low pressure) on-ground installations.

Pump pressure systems: A pump pressure system will be defined as any system that has working pressures greater than 15 psi. Use a rolled high-density polyethylene, or PVC pipe, for pressurized systems. Small pumps and low-yield wells may suffice for a relatively large herd of cattle if a large storage tank is available.

Table 3. Friction loss table for plastic pipe in feet/100 feet of pipe, nominal I.D./actual I.D.

gpm	3/4/0.824	1/1.049	1.25/1.380	1.5/1.610	2/2.067	2.5/2.469	3/3.216
2	1.0	0.3	—	—	—	—	—
4	3.7	1.2	0.3	0.1	—	—	—
6	7.9	2.4	0.6	0.3	—	—	—
8	—	4.1	1.1	0.5	—	—	—
10	—	6.3	1.6	0.8	0.2	—	—
12	—	—	2.3	1.1	0.3	—	—
14	—	—	3.1	1.5	0.4	—	—
16	—	—	3.9	1.9	0.5	—	—
18	—	—	4.9	2.3	0.7	—	—
20	—	—	—	2.8	0.8	0.3	—
30	—	—	—	—	1.8	0.7	—
35	—	—	—	—	2.3	—	—
40	—	—	—	—	3.0	1.3	0.3
50	—	—	—	—	—	1.9	0.5

Source: Midwest Plan Service publication MWPS-14, *Private Water Systems.*

System capacity

NRCS Practice Standards call for a system capacity of at least 30 gallons per day (at 90 degrees F) per 1,000 pounds live weight for supplying water to livestock. Pipelines (and pumps) should be sized to supply the peak demand of the herd in 12 hours or less. To supply water to tanks and waterers with limited animal access where many head will come to drink at a time, design to supply 2 gallons per minute (gpm) per head that can drink at one time. For example, if there is room for 6 cows to drink from the tank, the minimum flow rate to the tank should be 12 gpm.

When animals need water, they should not have to stand and wait. Studies have shown that best results are achieved when cattle are within 700 to 900 feet of the waterer. If the water is farther away, the cattle may come to the water as a herd rather than as individuals. Calves will get pushed back until the cows have finished drinking.

Pipe size to limit pressure drop

The size of the pipe needs to be matched to the demand (flow rate in gpm) and the travel distance in feet of pipe for that rate of flow, to keep the pressure drop through the pipe equal to (or less than) the pressure available. Table 3 gives the friction head loss in feet per 100 feet of pipe flow for various flows and pipe sizes (2.31 feet of head = 1 psi).

Friction loss for pipe fittings. Table 4 gives the friction loss for pipe fittings as an equivalent length of pipe as a function of the diameter. For example: The loss through a 2-inch globe valve fully open is equivalent to the loss through $340 \times 2 = 680$ inches of pipe = 56.67 feet of pipe length.

Table 4. Equivalent length in pipe diameters (L/d) of various valves and fittings.

Type of fitting	L/d
Globe valves, fully open	340
Gate valves, fully open	13
Gate valves, 3/4 open	35
Gate valves, 1/2 open	160
Swing check valves, fully open	135
In-line ball check valves, fully open	150
90 degree standard elbow	20–30
45 degree standard elbow	16
90 degree street elbow	50
Standard tee, flow through run	20
Standard tee, flow through branch	60

Example 1: Calculate the required system capacity to supply water to 100 head of cow-calf pairs that average 1,300 pounds / pair. NRCS Practice Standards call for a system capacity of at least 30 gallons per day (at 90 degrees F) per 1,000 pounds live weight for supplying water to livestock. The system capacity is calculated as follows:

$$\text{100 pairs} \times \text{1,300 lb/pair} \times \text{30 gal/(day-1,000 lb)} = \text{3,900 gal/day}$$
(round to 4,000 gallons)

Using the NRCS standard that the minimum flow rate should supply the herd's demand in 12 hours or less, the minimum system flow rate is calculated as follows:

$$\frac{\text{4,000 gal/day}}{\text{12 hr/day} \times \text{60 min/hr}} = \text{5.56 gpm (round to 6 gpm)}$$

Example 2: The watering tank on your farm that has the least gradient to produce gravity flow from a hilltop storage tank to the watering tank is 60 feet below the bottom of the storage tank and 4,000 pipe feet away. Therefore, for gravity flow, the maximum allowable friction loss per 100 feet of pipe is calculated as follows:

$$\frac{\text{60 feet}}{\text{4,000 feet}} = \text{0.0150 ft/ft} = \text{1.50 ft/100 ft}$$

From Table 3, we find that at 12 gpm (for 6 cows @ 2 gpm/cow), a 1½-inch diameter plastic pipe has a friction loss of 1.1 ft/100 ft, which is well under 1.5 ft/100 ft. Therefore, 1½-inch pipe is required (disregarding miscellaneous friction losses for fittings, valves, etc.).

Based on 1½-inch pipe, find the additional friction loss if the pipeline has a fully open gate valve, three tees, one 90 degree elbow at the tank and the float valve in the tank has a loss equivalent to a gate valve half open (L/d = 160).

Calculate the equivalent length of the friction loss through the fittings as follows:

Gate valve: L/d = 13 = L/1.5";	L = 1.5" × 13 = 19.5 in
Three tees: L/d = 20 = L/1.5";	L = 3 × 1.5" × 20 = 90 in
90-degree elbow: L/d = 25 = L/1.5";	L = 1.5" × 25 = 37.5 in
Float valve: L/d = 160 = L/1.5"	L = 1.5" × 160 = 240 in
	Total equivalent length = 387" = 32.25 feet

Add the fitting friction loss and recalculate the allowable friction loss as follows:

$$\frac{\text{60 feet}}{(4{,}000 + 32.25)/\text{100 ft}} = \text{1.49 ft/100 ft}$$

This compares with1.50 ft/100 ft without fittings.

Therefore, we usually neglect the fitting loss in selecting the required pipe diameter, and the 1½-inch pipe will be adequate.

Example 3: For your herd of 100 cows and calves that will require about 39 gallons of water per pair per day in hot weather, you wish to provide 8,000 gallons of storage for two days' consumption. Assume you want to fill the tank in 6 hours with a solar-powered pump. A minimum pumping rate and power requirement to fill an 8,000-gallon storage tank to be placed on the highest hill on the farm at 2,200 feet from the water source with the full water level in the tank 130 feet above the water level at the source is calculated as follows:

$$\frac{\text{8,000 gallons}}{\text{6 hr/day} \times \text{60 min/hr}} = \text{22.2 gpm (round to 22 gpm)}$$

Select a pipe to convey the water for 2,200 feet with a reasonable friction loss in the pipe. From Table 3, for a flow rate of 22 gpm, we select a 2-inch pipe and interpolate between 20 gpm and 30 gpm to use 1.0 ft per 100 ft for the friction loss. If we ignore the loss in pipe fittings for this calculation, the friction loss through the 2,200 foot pipe is given as follows:

$$\text{1.0 ft/100 ft} \times \text{2,200 ft} = \text{22 feet}$$

The elevation difference (130 ft) plus the friction loss (22ft) = 152 ft (equal to 65.8 psi)

The power required to pump water is:

$$\frac{\text{gpm} \times \text{pressure in feet}}{\text{3,960} \times \text{pump efficiency*}} = \text{motor horsepower (hp)}$$

* Pump efficiency expressed as a decimal.

We will assume a pump efficiency for this application at 50 percent.

$$\text{motor hp} = \frac{\text{22 gpm} \times \text{152 ft}}{\text{3,960} \times \text{0.50}} = \text{1.7 hp (minimum)}$$

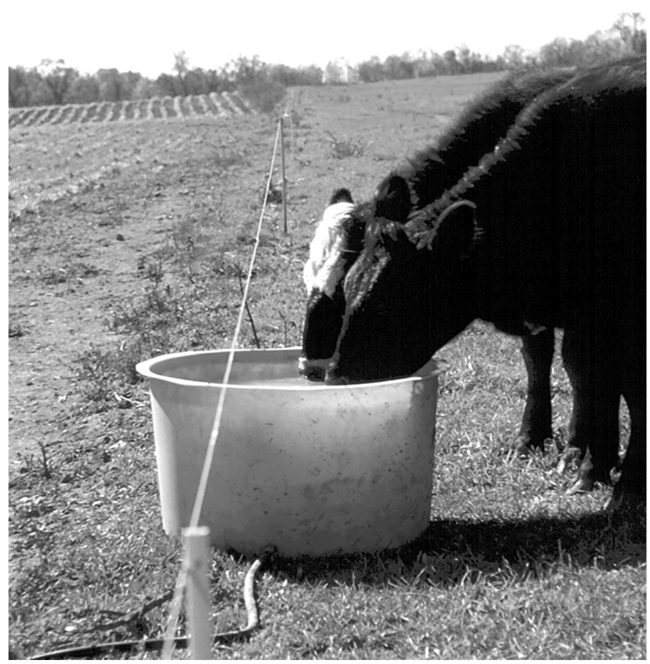
To provide electricity for the pump motor, assume we want to select solar panels that have a wattage at least 25 percent greater than the DC motor wattage. One horsepower = 746 watts.

$$\text{1.7 hp} \times \text{746 watts} \times \text{125\%/100} = \text{1,585watts (minimum)}$$

Sizing the tank and waterer

Sizing the water volume of the tank and the perimeter of the tank (for access by a certain number of cattle) must take into consideration the distance to water in addition to the herd size (number of animals). Cost per gallon of capacity goes down rapidly with increase in tank capacity.

Small (lightweight) UV-stable, high-density polyethylene portable tanks (14 to 60 gallons) with float valves and quick couplers cost about $100 to $150 (Figure 2). These small tanks will water a large number of cattle if the animals are close to the tank and come singly or if the recharge rate is at least equal to the rate at which the cattle can drink the water (2 gpm times the number of cows that can drink from the tank at one time). Figure 3 shows a larger tank that can be used year-round with a



Copyright Kentucky Graziers Supply

Figure 2. Most management-intensive grazing systems make use of lightweight portable poly tanks. With quick disconnects, they can be easily carried from paddock to paddock.

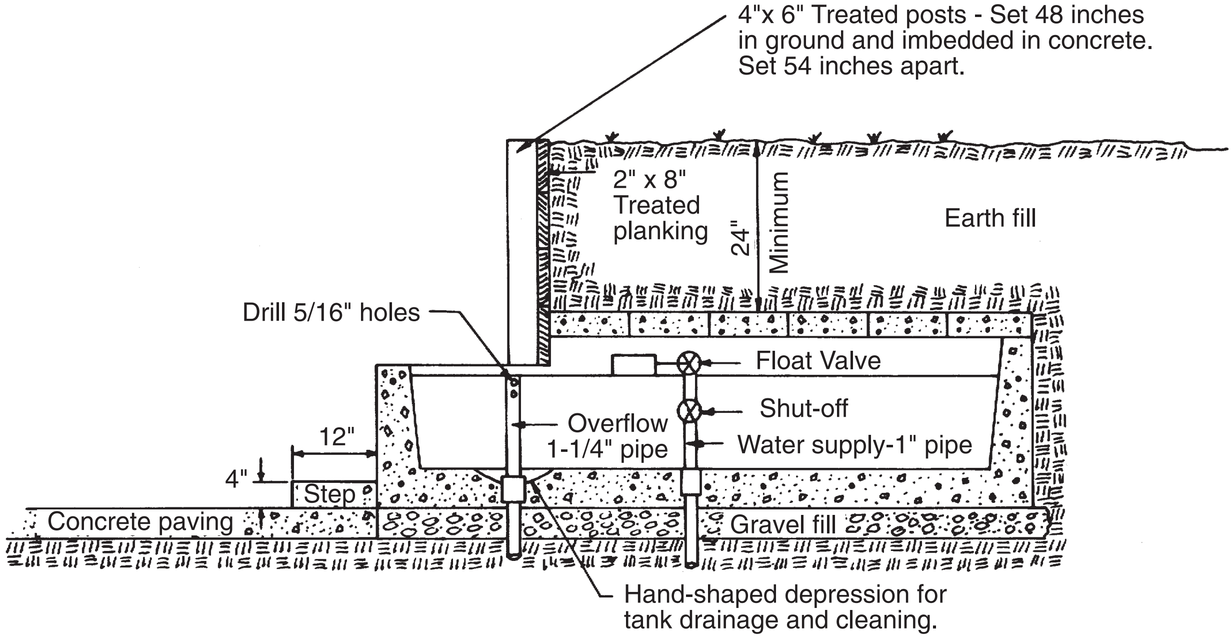


Figure 3. This "freeze proof" tank depends on an earth berm for insulation and a "trickle overflow" to bring in warm water to prevent freezing in severely cold weather. See MU publication G1161, *All-Weather Concrete Stock Tank.*

small flow of water through the tank to prevent freezing.

Sizing the tank volume: If the distance to water is greater than 800 feet, size the tank volume for 1/3 of the daily herd requirement. If water is close, size the tank volume for 1/50 of the herd requirement.

Example for distance greater than 800 feet: You have 30 lactating cows with calves in the herd and they have to travel 1,100 feet to water with the temperature at 90 degrees. The tank volume should be as follows:

1/3 × 30 head × 39 gallon per head per day = 390 gallons

Estimating the tank access space: Estimate the access space by multiplying ⅓ or ⅒ of the herd number, depending on proximity of water to the pasture, by 15 inches space per animal.

Example: You have 30 lactating cows in the herd and they have to travel 1,100 feet to water. The tank space should be as follows:

1/3 × 30 head × 15 inches/head = 150 inches

Assume that you are using a round tank in the fenceline between two pastures so that the cows can access half the circumference of the tank. Find the required tank diameter, as follows:

Circumference (C) in feet = 3.14 × diameter (D) in feet.
Therefore, required diameter = 2 × C/3.14 = 2 × 150/3.14
= 96 inches = 8 feet
Note: C = π × D = 3.14 × D

Check for depth of tank to hold 390 gallons. Volume, $V = 390 \text{ gallons} = \pi \times (D/2)^2 \times d \times 7.5 \text{ gal/cu ft} = \pi \times D/2 \times D/2 \times d \times 7.5 \text{ gal/cu ft} = 3.14 \times 4 \times 4 \times d \times 7.5 = 376.8 \times d = 390$ gallons (where $\pi = 3.14$, D = diameter of tank = 8 feet, and d = depth of water to equal 390 gallons in the tank).

376.8 × d = 390 gallons; d = 390/376.8 = 1.04 feet deep

Most large tanks are about 2 feet deep. Therefore the tank size is determined by the access space around the tank for cattle to drink and not by the quantity of water the cattle will drink at one time.

Example for distance less than 800 feet: You have the same 30 lactating cows with calves in the herd but they have to travel only 600 feet or less to water; with the temperature at 90 degrees, the tank volume should not be less than:

1/50 × 30 head × 39 gallons per head per day = 23.4 gallons

This size tank can be carried from paddock to paddock and be quickly attached to a pipeline with a "quick disconnect."

Estimating the tank access space

Example: You have 30 lactating cows in the herd and they have to travel 600 feet, or less, to water, the tank access space should be:

1/10 × 30 head × 15 inches/head = 45 inches

Assume that you are using a round tank in the fenceline between two pastures so that the cows can access half the circumference of the tank. Find the required tank diameter, as follows:

Circumference, C in feet = 3.14 x diameter, D in feet.
Therefore, required diameter = 2 × C/3.14 = 2 × 45/3.14
= 29 inches = 2.4 feet

(Note: C = π × D = 3.14 × D)

To keep the tank from going dry, we need a flow rate of about 6 gpm so that three cows can drink at the same time without having to wait for the tank to refill (a cow can drink at the rate of about 2 gpm).

Tanks for emergency water storage: Depending on the herd size, the complexity of the watering system and the risk of a system breakdown, having a reserve supply of water should be considered. If a water hauler is readily available, having movable water tanks holding a one-day supply of water available to take to each pasture may be sufficient. At the other extreme, storage for up to three days of use with an alternate means of transporting the water to the cattle, or the cattle to the water, may be justified. In some cases, the reserve storage tank could be located at the highest point on the farm with a secondary gravity-flow pipeline to major pastures.

Pumps for remote locations

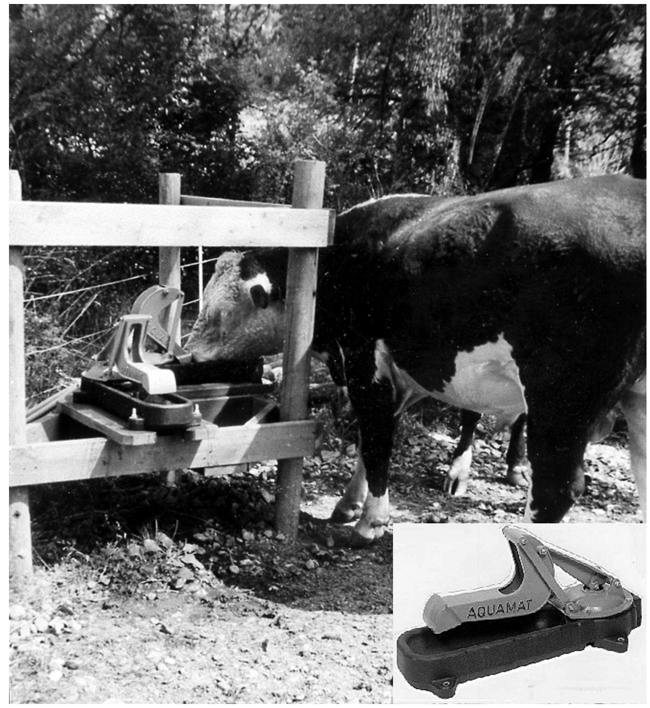
For most pasture locations where water cannot be conveyed by gravity, "high-line" electrical power is frequently not available without undue cost for extending lines. Wind and solar technology (photovoltaic conversion of sunlight to electrical energy) offer alternative energy sources for pumping water for livestock. These systems generally cost between $1,500 and $4,000 to install, depending on the quantity of water to be pumped, lift required, distance the water is pumped, and the sophistication of the equipment.

A solar panel, a low-voltage electrical motor and a small pump with wiring and controls constitute the minimum solar energy equipment package. To store energy for use when sunshine is not available, batteries or a water storage tank may be required. Try to provide three days of electrical storage with batteries or a three-day supply of stored water (also for windmills). Systems without automatic controls should be closely matched to need because excess water pumped will overflow the storage structure. Controlled overflow is needed to avoid erosion and wet ground around the tank.

Most solar pumping systems operate on 12 or 24 volts and 3 to 4 amps of direct current (a range of watts from 36 to 96). Considering that one horsepower equals 746 watts at 100 percent efficiency, we are dealing with very low-power motors.

Most solar pumps are low volume, yielding 2 to 5 gpm at various pumping heads depending on the type of pump. The solar array should have a capacity of at least 25 percent more watts than the pump requires. Having one reliable supplier design and supply the solar pumping system is recommended.

For low lifts, another recent alternative is the nose pump operated by the animal. Nose-operated pumps work well for cattle, but in most cases are too difficult for calves to operate (Figure 4). Each pump can handle between 20 and 25 cows. These pumps cost about $400 and allow versatility in drawing water **short** distances from ponds, streams, and shallow wells. Therefore, they have limited application where it is desirable to have water in every paddock. Maximum lift is about 24 feet; a lift of 15 to 20 feet is more realistic. It is important to have an adequately sized line to the water supply (see Table 5).



Courtesy Blue Skies West

Figure 4. This nose pump uses animal power to pump water from a stream to the watering cup.

Table 5. Pipe diameter vs. distance for nose pumps.

Distance (feet)	Pipe diameter (inches)
50	1
50–150	1.25
150+	1.50

Gas- or diesel-powered pumps offer high labor alternatives for pumping water to reservoirs and large water tanks. Various levels of automation can be applied. Automatic shut-off is fairly simple to accomplish; however, automatic start is a more complex operation.

Other pumping devices that do not require external power sources include water or hydraulic rams, water wheels, and sling pumps. Such devices cost between $500 and $1,000, but they are appropriate only in unique locations and situations. For example, sling pumps require flowing streams 12–18 inches deep. Water rams are driven by the force of flowing water and work only where water can be piped from the source to lower ground, where the ram works on a hydraulic principle and forces a portion of the water to higher elevations (Figure 5).

Hydraulic rams waste large amounts of water. They seldom pump more than 20 percent of the water required for operation and frequently less than 10 percent. Therefore, provisions for draining tailwater away from the ram must be provided when using this pumping device. Example: A particular make and model of ram claims to have the following capability: With 12 feet of vertical fall to the ram and pumping to an elevation of 125 feet, 5.7 percent of the water will be delivered at a rate of about 2.25 gpm.

Spring development

Large flowing springs may provide flowing water year-round like a stream. Smaller springs may have to be developed to collect water to be accessed directly or piped by gravity or pumped to other locations. For details on spring development contact your NRCS office or see MWPS-14, *Private Water Systems Handbook*.

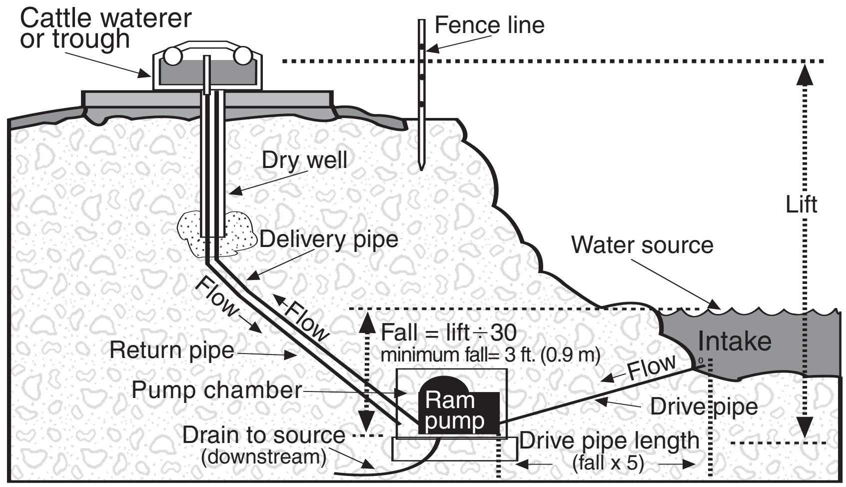


Figure 4. A ram pump can be used to elevate water but requires much more water for power than it delivers.

Hauling water

Long-term grazing systems should not be developed on the basis of hauling water to livestock in water wagons, although this might be considered as a temporary solution or in emergency situations. The cost of hauling water one mile is about $0.01 per gallon.

For further information

Agricultural Waste Management Field Handbook. Part 651, National Engineering Handbook. Washington, D.C.: Natural Resources Conservation Service, U.S. Department of Agriculture, 1992.

Livestock Management in Grazed Watersheds, Publication 3381. UCD Animal Agriculture Research Center & UC Agricultural Issues Center, Division of Agriculture and Natural Resources, Communication Services-Publications, University of California, Oakland, Calif. 1996.

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Sheffield, R.E., S. Mostaghimi, D.H. Vaughan, E.R. Collins and V.G. Allen. 1997. *Off-stream Water Sources Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP.* Transactions of the American Society of Agricultural Engineers 41:3, 595–604.

Stockman's Guide to Range Livestock Watering from Surface Water Sources. Humbolt, Saskatchewan: Prairie Agricultural Machinery Institute, 1995.

Turner, W.M. 1996. *Watering Livestock with Solar Water Pumping Systems*. Jefferson City, Mo.: Missouri Department of Conservation.

Watering Systems for Grazing Livestock. Great Lakes Basin Grazing Network and Michigan State University Extension.

Available from Extension Publications 1-800-292-0969

MU Publications

G 1161 *All-Weather Stock Tank*

Midwest Plan Service Publications

MWPS-6 *Beef Housing and Equipment Handbook*

MWPS-14 *Private Water Systems*

Sources of supply

Most manufacturers of water pumping and livestock watering systems have guides for installation. A number of these companies or their dealers are listed below. This list is not inclusive and does not imply an endorsement or recommendation of these products or suppliers by the University of Missouri or by the authors.

Solar pumps

Solar Water Technologies Inc.
4329 Roanoke Parkway; Suite 2-S
Kansas City, Missouri 64111
Phone: (800) 952-7221
Phone: (816) 531-6151

Farm Products Direct
Highway 9 North, Box 181
Herman, MN 56248
Phone: 1-800-669-9314

SolarJack Division of Photocomm, Inc.
P.O. Box 14230
Scottsdale, AZ 85267-4230
Phone: 602-951-6330

Sun Electric Co.
P.O. Box 1499
Hamilton, MT 59840
Order Line: 1-800-338-6844
Tech Line: 1-406-363-6924

Robinson Solar Systems
404 Loomis Road
Weatherford, OK 73096
Phone: 580-774-2200

Dankoff Solar Products, Inc.
1807 Second St., Unit #55
Santa Fe, NM 87505
Phone: 505-820-6611

Sierra Solar Systems
109 Argall Way
Nevada City, CA 95959
Phone: 1-888-667-6527

Ozark Solar
314 East Spring Street
Neosho, MO 64850
Phone: 1-800-711-4756
417-451-4756 or 0053

Various alternate energy pumps

Jetstream Power International
P.O. Box 98
Holmesville, OH 44633
Phone: 330-279-4827

Rife Hydraulic Engine Mfg. Co.
P.O. Box 70
Wilkes-Barre, PA 18703
Phone: 1-800-RIFE-RAM
717-823-5730

Nose pumps

Blue Skies West
110 Michigan Hill Road
Centralia, WA 98531
Phone: 1-888-NOSEPUMP
360-736-2475

Farm'Trol Equipment
409 Mayville Street
Theresa, WI 53091
Phone: 920-488-3221

Tanks, valves, waterers

Green Hills Grazing Systems
Rt. 1, Box 57
Winigan, MO 63566
Phone: 660-857-4474 (Tech. Assistance)
1-800-748-7259 (Orders Only)

McBee Agri Supply
16151 Old Highway 63 North
Sturgeon, MO 65284
Phone: 573-696-2517

MFA Incorporated
201 Ray Young Drive
Columbia, MO 65201
Phone: 573-874-5111
or
Your local MFA Agri Service

American Feed & Farm Supply (Wholesale)
1519 West 16th Street
Kansas City, MO 64102
Phone: 1-800-892-5868

Kentucky Graziers Supply
1929 South Main Street
Paris, KY 40361
Phone: 1-800-729-0592

Zeitlow Distributing Company
P.O. Box 85
Boonville, MO 65233
Phone: 660-882-2762

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