Waterers and Watering Systems:
A Handbook for Livestock Producers and Landowners

K·STATE
Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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Introduction

Why should I be concerned about livestock water quality?

Livestock tend to congregate around water sources. This can lead to reduced vegetative cover and increased manure concentration in and around water sources. The water source can become polluted with sediment, nutrients, algae, bacteria, and other microorganisms, leading to low water quality. Poor quality water affects livestock by impairing health and animal performance.[1] Livestock may respond to low water quality by reducing both water intake and time spent grazing, adversely influencing weight gains.[2]

1 *Umar S, Munir MT, Azeem T, Ali S, Umar W, Rehman A, Shah MA. 2014. Effects of water quality on productivity and performance of livestock: A mini review. Veterinaria 2: 11-15.*

2 *Willms, W.D., O.R. Kenzie, T.A. McAllister, D. Colwell, D. Veira, J.F. Wilmshurst, T. Entz, and M.E. Olson. 2002. Effects of water quality on cattle performance. J. Range Manage. 55:452-460.*

How can I change the drinking and loafing behavior of my livestock?

Livestock distribution can be altered by manipulating livestock attractants. Water is the strongest attractant, both for drinking and loafing. Other attractants include mineral and salt feeders, oilers and scratching posts, gates, shade, wind protection (winter), breezy heights (summer), feeding areas, patches of highly palatable forage, and cattle in adjacent pastures. Removing, adding, or redistributing attractants can alter the drinking and loafing behavior of cattle.[3]

3 *Bailey, D. 2005. Identification and creation of optimum habitat conditions for livestock. Rangeland Ecology & Management 58:109-118.*

Cattle spend as little as 4 minutes a day drinking but can spend 10 times as long loafing around the water source.[4] Loafing behavior increases the water quality problems associated with water distribution points. Loafing can be minimized by locating other attractants in distant areas of the pasture and making the area near the water source less comfortable for loafing, such as adding a gravel surface (Photo 1). Providing a water source away from a stream can reduce the time spent by cattle in the riparian area by up to 96%.[5]

How can I use my water resources to meet both the needs of my livestock and water quality concerns?

Existing water resources can be renovated or modified and new sources of water can be added to provide adequate water and livestock access while protecting water quality. Frequently, an existing water source can be used with a relocated distribution point (waterer or tank). The area around a water distribution point can be protected to reduce mud and erosion problems.

How can water be made available to animals?

There are three main methods to deliver water to livestock:

- Provide direct access to a water source such as a stream or pond;
- Allow water to flow by gravity from a higher elevation into a waterer or tank;
- Pump water from a lower elevation to a higher elevation into a waterer or tank.

Water delivery is often a combination of the water source, a power source, a pipeline to convey the water to the waterer, and the waterer itself. Each component of the watering system should be

4 *Clawson, J. E. 1993. The use of off-stream water developments and various water gap configurations to modify the watering behavior of cattle. M.S. Thesis, Oregon State University.*

5 *Byers, H.L, Cabrera M.L., Matthews M.K., Franklin D.H., Andrae J.G., Radcliffe D.E., McCann M.A.,. Kuykendall H.A, Hoveland C.S. and Calvert II V.H.. 2005. Cattle use of riparian areas in the Georgia Piedmont, U.S.A. J. Environ. Quality.*

Photo 1. *Cattle congregating under trees can destroy vegetation especially if the trees are located near a water source.*

selected for compatibility with the entire watering system and livestock needs.

How do I decide which components to use?

This handbook assists in the design of a watering system that fits your budget, site, and livestock needs. Some systems require specific geological formations (such as springs) or depend on specific elevation differences. While components may be off-the-shelf, the arrangement and installation of a watering system must be adjusted to each site. As you look through this handbook, keep in mind the characteristics of your land and site, the time you have available for management and upkeep, and the size and type of animal you have. These will all factor into decisions about which option to choose.

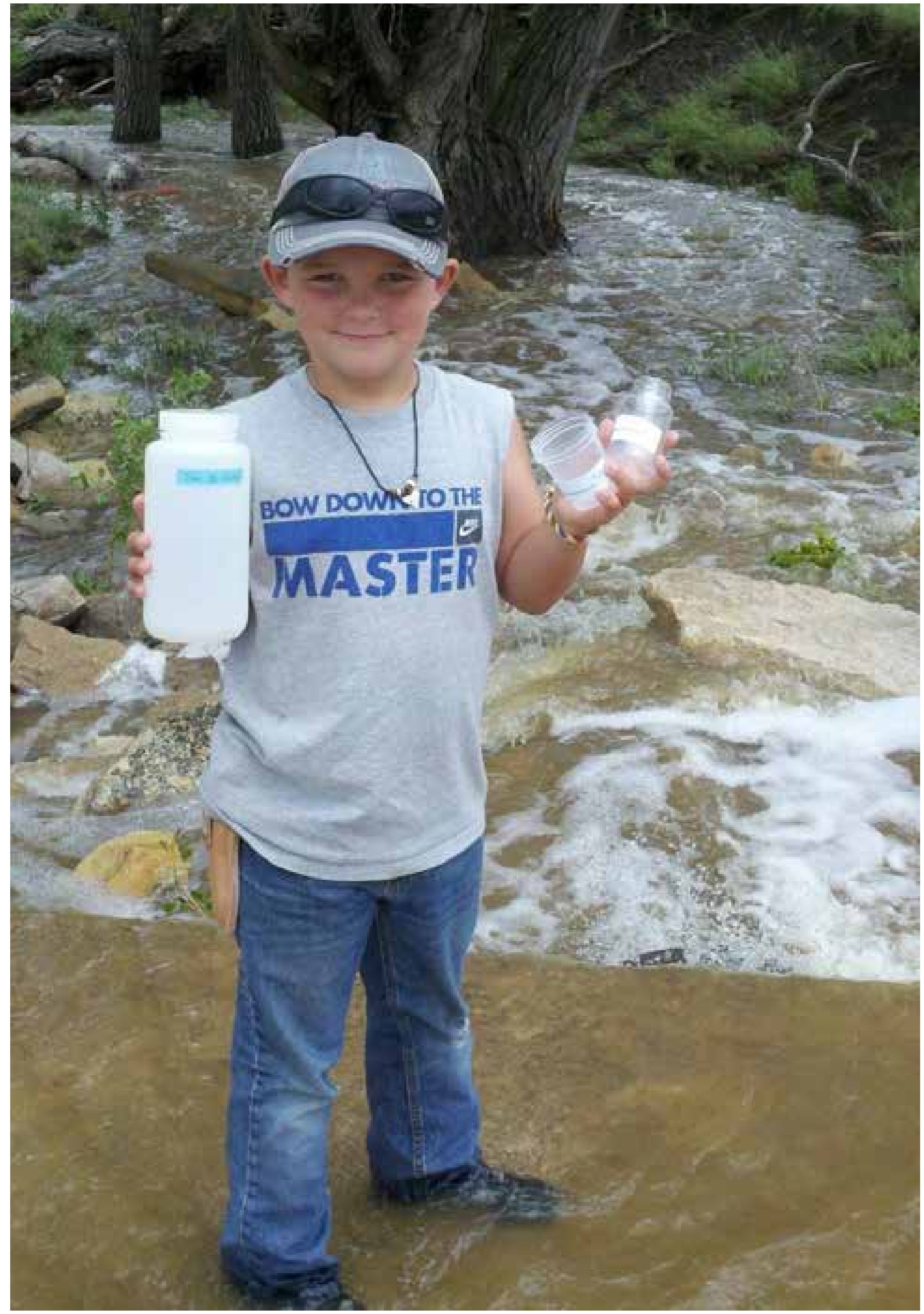
What contributes to poor water quality?

A variety of factors contribute to poor water quality and ultimately result in poor livestock performance or death. Mineral, biological, and chemical components can impair water quality (Table 1). Drought conditions can concentrate components as water levels drop. Manure runoff often affects multiple water-quality constituents, such as nitrates, blue-green algae, and undesirable bacteria. Tolerance to each constituent varies by species, health condition, age, and season. Providing livestock with improved access to plentiful, clean water is a good reason to upgrade a watering system.

Mineral Components

Alkalinity, or high pH, is generally determined by the geology of the water source. Water with a high pH is common in Kansas. Cattle rarely have problems with alkaline water, but high pH values can reduce feed and water consumption and cause digestive upsets.

Salinity (total dissolved solids) is generally determined by the water source geology. Livestock can tolerate a wide range of salinity but will avoid drinking high salinity water when other water sources are available. Oil field activities can influence water salinity. High salinity can cause diarrhea, weakness, tremors, paralysis, and unfocused wandering.



Animals may refuse to drink highly saline water and then gorge, causing severe health problems. It is difficult to remedy high salinity levels, and providing another source of clean water may be the only option.

Sulfates in the water can be aggravated by additional consumption of dietary sulfur, resulting in mineral imbalances. High levels of sulfate can result in brain disorders, mineral deficiencies, poor conception, and death. It is difficult to remedy high sulfate levels, and providing another source of clean water may be the only option.

Calcium and magnesium are common in water and are rarely a problem as their relative insolubility allows them to pass harmlessly through the body. In combination with sulfates, laxative effects are increased.

Nitrates are associated with fertilizer, manure, or decaying animal matter contamination of the water source, and can also be found in toxic quantities in grazed or hayed feed. Nitrate poisoning decreases blood oxygenation and can lead to death. Preventing nitrates from entering the water is the most effective remedy. Nitrates in both feed and water need to be considered when calculating nitrate poisoning risk to livestock.

Blue-green algae (cyanobacteria) release toxins as they die. See the chapter titled *Blue-Green Algae*.

Bacteria, viruses, and parasites can cause leptospirosis, coccidiosis, and footrot in livestock. Biological contaminants can be introduced into water sources by manure deposition and runoff into surface waters, and through cracked well casings in drilled wells.

Hard water contains calcium and magnesium. It is generally not a livestock health problem but can affect components of the watering system. Do not use water softeners if the water salinity level is already high.

Chemical and industrial products can enter water though leaks, disposal activities, or in runoff after application. Pipeline spills can be a contaminant source in areas of oil production. Hydrocarbons (oil) ingestion symptoms include constipation, bloat, digestive disorders, weight loss, immune suppression, respiratory disorders, and nervous system disorders. Reproduction may also be affected. Chemical contamination can be long lasting and may require sustained monitoring as well as moving livestock away from contaminated areas and water supplies.

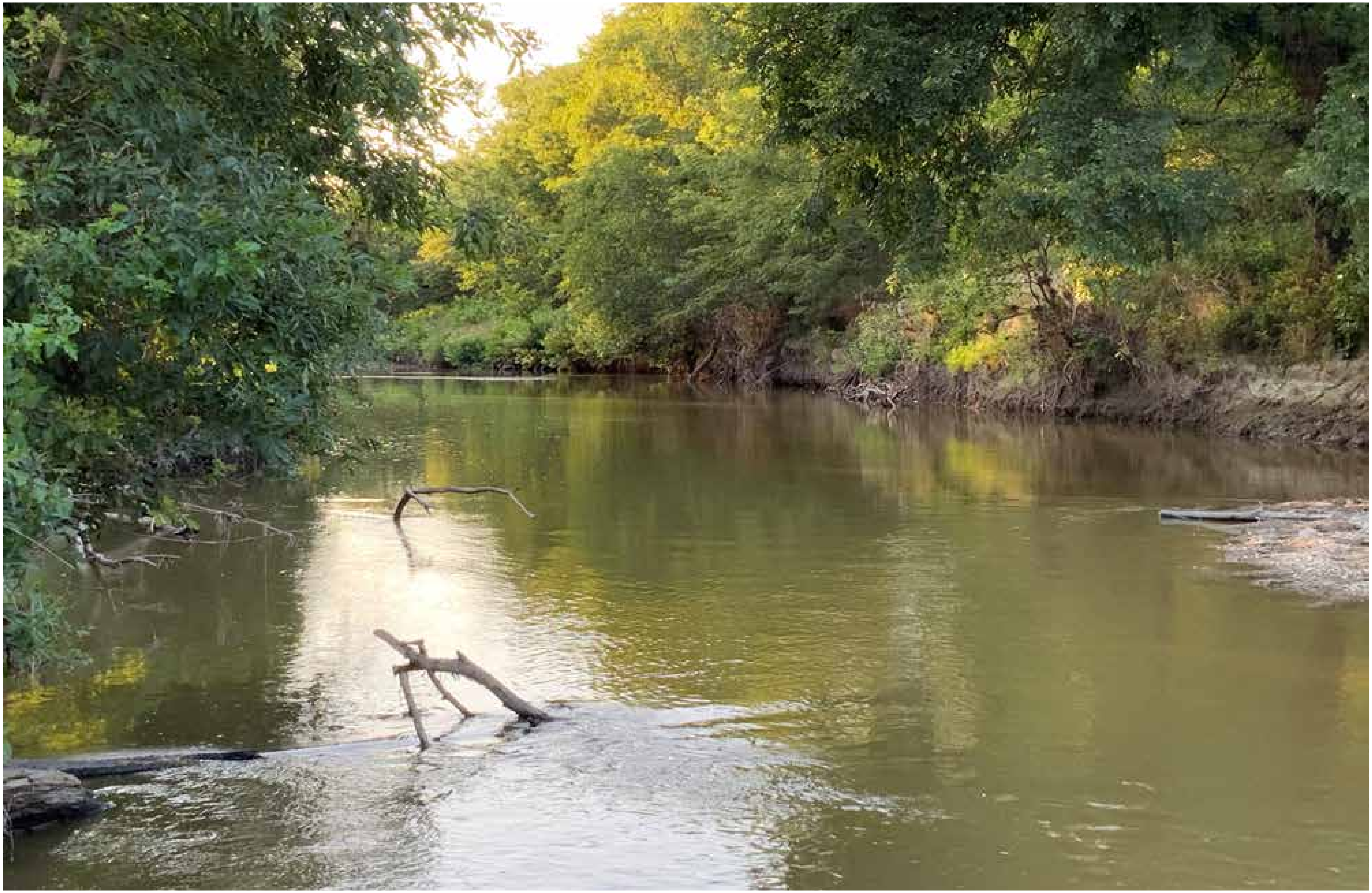
Water testing can identify water quality constituents and should be done routinely in situations where the water source is shallow, under drought conditions, or if a water-quality problem is suspected. Electrical conductivity meters can be used on site to test for salinity. Water samples can be collected and sent to a lab for analysis. Sampling should be done in accordance with lab instructions.

Table 1. *Water Quality Constituent Ranges for Cattle*[1]

Constituent	Reduced performance	Unsuitable for beef cattle
Nitrate (ppm)	400-1,300	>1,300
Salinity (ppm)	3,000-7,000	>7,000
Sulfate (ppm)	500-3,300	>3,300
Fecal coliform (per 100 ml)	1,000-2,500	>5,000
pH	>8.5	>10

[1] Braul L., Kirychuk B. 2001. Water quality and cattle. Agriculture and Agri-Food Canada ENH-111-2001-10. 6 pp.
Meehan, M.A. Stokka, G. Mostrom, M. 2021. Livestock water quality. North Dakota State University Extension AS1764. 4 pp.

Water Sources



Waterer Comparison Chart

Source	Primary Advantages	Primary Limitations	Initial Cost	Maintenance Cost
Stream	• Naturally occurring, no direct installation cost.	• Water may become stagnant and of poor quality during periods of low flow. • Can have high levels of bacteria. • Floods can cause maintenance issues (repair of fences and crossings).	$	$-$$
Pond	• Does not involve mechanical or electrical parts that can fail. • Can be used for recreational purposes too.	• Direct livestock access can cause poor water quality and damage structural integrity. • High initial cost. • Periodic restoration (silt removal). • Variable supply depending upon precipitation.	$$$$	$
Spring	• Relatively inexpensive. • Small flows can be developed into a water supply.	• Not present in all locations.	$-$$	$
Water Intake Structure	• Simple and inexpensive. • Reduces sediment and nutrients entering streams and ponds.	• Stream or pond access required. • May require rental equipment or contractor to install. • Not a common installation in Kansas.	$-$$	$
Well	• Consistent water quality. • Long useful life. • Reduces chances of surface water contamination.	• Groundwater may be deep, increasing installation costs. • Aquifer not present in all locations. • Power source needed to pump water.	$$$-$$$$	$
Rural Water District	• Reliable supply. • High water quality.	• Not available in all locations. • Pipeline from waterer to district line may be long and expensive to install. • Minimum water use charges apply year-round. • Membership and meter fees.	$-$$$	$
Hauled Water	• Very mobile. • Adapted to short-term grazing.	• Labor intensive. • Muddy/snowy conditions may complicate water delivery. • Water may be wasted when valve not turned off.	$	$$-$$$

Pond and Pit

Overview

Ponds are a common source of livestock water throughout much of Kansas. They generally store large quantities of water, can be constructed in various settings, and may provide other benefits such as recreational opportunities, erosion control, and flood protection. High initial cost, summer stagnant water, and the eventual need for dredging may lead to selection of another watering option. Concerns about sedimentation and water quality justify the consideration of other water sources. Fencing livestock out of the pond, using a hardened watering point, or installing a pipeline through the dam to a tank below can mitigate some of these problems.

Advantages

- Simple and adaptable to many locations.
- No mechanical or electrical parts to fail.
- Can store a long-term supply of water.
- Contractors are familiar with construction and maintenance.
- Can be used for fishing and other recreational activities.
- Can be designed for detention of heavy runoff to reduce flooding downstream.
- Pipeline through the dam can be used to flow water into a tank below the dam.

Limitations

- Sedimentation and bank erosion decrease the amount of water that can be stored and reduce pond life.
- Direct livestock access can decrease water quality.
- Initial construction and later restoration costs are high.
- Steep banks and mud can be hazardous to livestock in wet conditions.
- Animals walking on the pond in the winter may fall through the ice.

- A hole may need to be chopped in the ice to provide water for livestock in winter.
- Emergency spillway erosion requiring repair is common.
- Runoff needed to refill the pond is limited and sporadic in low-rainfall areas.
- Not suitable for sandy or rocky soils.
- Ponds that do not hold water are difficult to remedy.
- Water quality may be impacted by blue-green algae growth.
- Ponds require a professional design.

Design Considerations

Most ponds are constructed by excavating material that is used to build an embankment (dam) across an incised drainage. Pond size is a result of the natural depth of the drainage and the amount of soil excavated for the dam. In broad, flat drainages, a pit can be excavated to collect runoff and store water. Pits may also be located outside of drainages in situations where they are supplied by an underground flow.

Size and location are critical factors when designing livestock ponds. Unless they are continuously supplied by springs and underground flow, ponds should be sized large enough to store water to supply livestock throughout extended dry periods (generally two years) of high evaporation and no runoff. The landowner is responsible for the safe operation and maintenance of the dam. When siting a dam, consider any downstream development that would be affected during periods of restricted water flow during dry weather, or dam failure during wet weather.

Pond design should include a primary spillway or trickle pipe for a controlled release of the water as well as a flatter emergency spillway at the end of the dam to carry away excess water during high rainfall events. Careful sizing of the trickle pipe and water storage relative to the size, slope, and landcover of the drainage will decrease the incidence of erosion in the emergency spillway. The dam and other disturbed soil should be seeded shortly after construction to stabilize the soil.

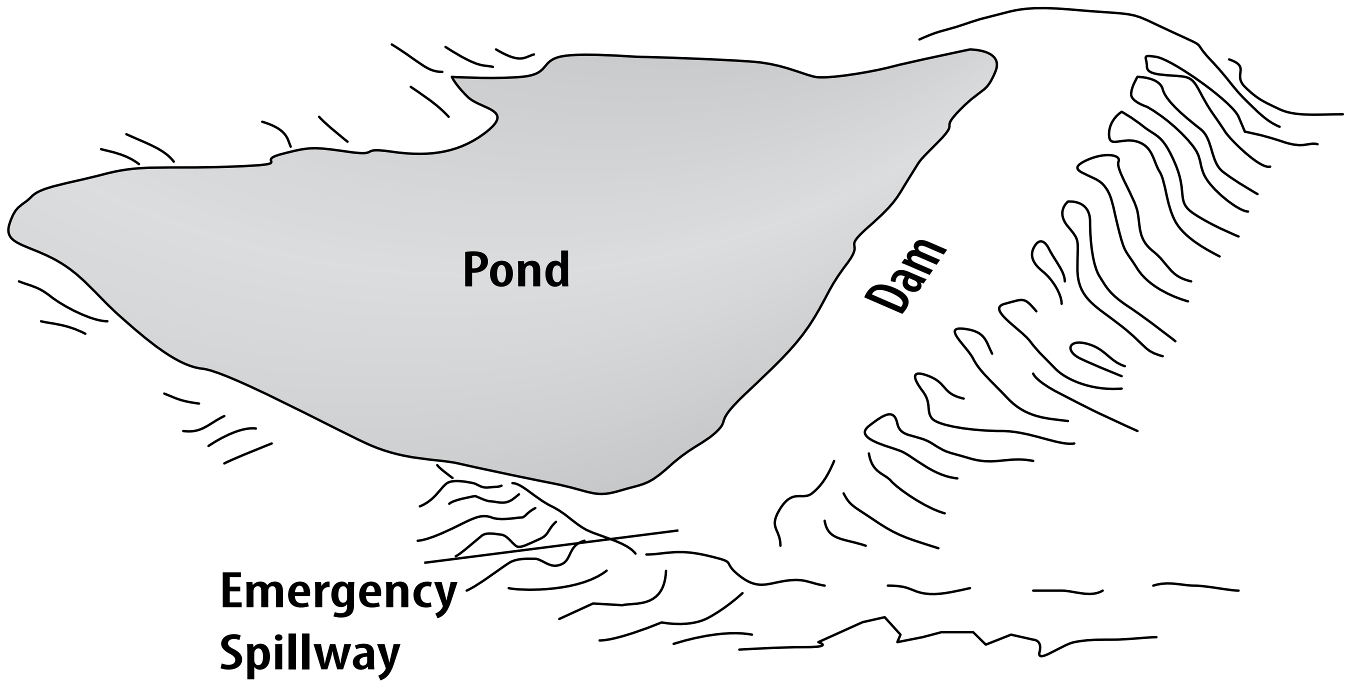
Pond location is dictated by landscape features, but where possible, locate the pond to improve grazing distribution. Shade, salt and mineral feeders, which also attract livestock, should be located away from the pond to prevent overuse of nearby vegetation.

Installation of water supply lines under or through the dam and fencing to allow limited or no direct livestock access will improve pond water quality and extend the life of the pond.

NRCS can provide technical assistance for designing and installing a pond.

This practice may require permits. Please read the “Permits in Kansas” section of this handbook.

Dams can also involve water rights. For more information, search for “water rights and dams” at the Kansas Department of Agriculture website: *agriculture.ks.gov* .


Pond
Dam
Emergency
Spillway

Pond Fencing

Overview

Ponds can be important sources of livestock water and serve other purposes such as runoff retention, erosion control and aquatic wildlife habitat. Most ponds lose some usefulness over time due to erosion and sedimentation. Eliminating unrestricted livestock access to the pond with fencing can extend its useful life. A fenced pond requires an alternative method of allowing livestock to use the water, such as installing a pipeline through the dam to a tank or construction of a limited-access ramp to the pond. Rotational grazing of the pasture may also provide some of the same benefits as fencing, as livestock are limited in the amount of time spent in the pasture with the pond.

Advantages

- Minimizes erosion of pond shorelines and dam faces.
- Reduces sediment deposition in pond.
- Extends useful life of the pond.
- Improves water quality for livestock and aquatic life.
- Improve wildlife habitat along the shoreline.
- Prevents cattle from walking out on the ice and falling into the pond.
- Eliminates livestock trails on the dam or in the emergency spillway that cause erosion.
- Minimizes transmission of diseases related to fecal deposition in the water.

Limitations

- Additional cost of fencing, including numerous corners due to irregular shaped fenced-out area.
- Additional cost of installing a waterer or limited access watering point.

Design Considerations

Testing the layout of a pond fence with electric fencing for a year or two before installing a permanent fence may reveal problem areas that can be addressed in the final fence installation. Eliminating or minimizing the number of sharp corners in the fence reduces potential erosion from livestock trails. Steep topography may add to the cost of the fence. A standard fence of four barbed wires with posts at 16- to 20-foot intervals is adequate in most situations.

The fence should provide an adequate buffer between the edge of the pond and the grazed area outside the fence. At least 30 feet of buffer is necessary to filter out sediment and nutrients. Grass cover is preferable to woody cover to maintain good water quality. Buffers are often used by ground-nesting birds; if they are too narrow, predators easily find the nests. Installing a gate in the fence allows flash grazing of pond buffers

Table 2. *Application Rates*

Material	Application Rate (pounds per 100 sq. feet)	Notes
Bentonite	100 to 150 (silty soils) 200 to 300 (sandier soils)	Most expensive
Soda ash	10 to 25	Makes a good seal. Soil must contain >15% clay + 50% clay/silt soil
Rock salt	20 to 33	Least expensive. Application during new construction is unlikely to harm fish.

For more information on pond sealing:

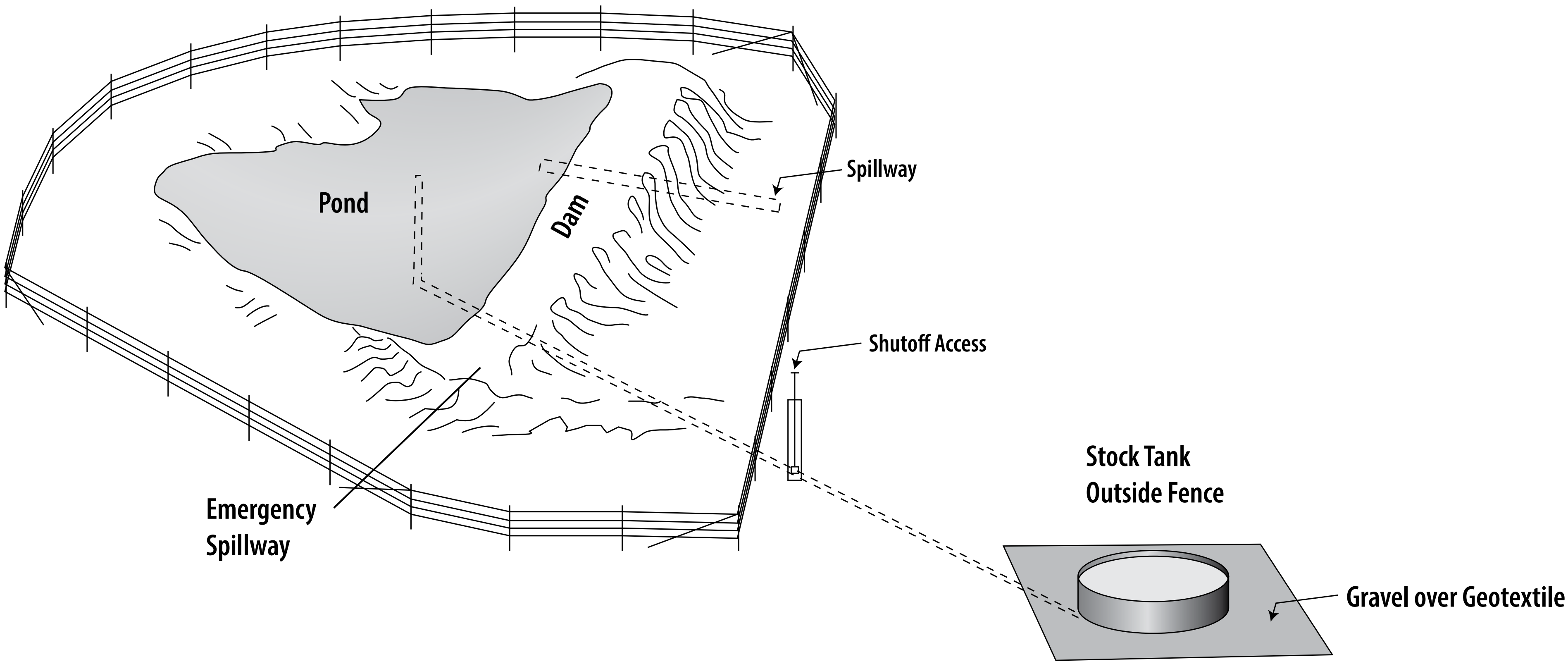
Reducing Pond Seepage. Pfost D. L., Williams, D., and Koenig R. University of Missouri Extension, 1997 *https://extension.missouri.edu/publications/g1555*

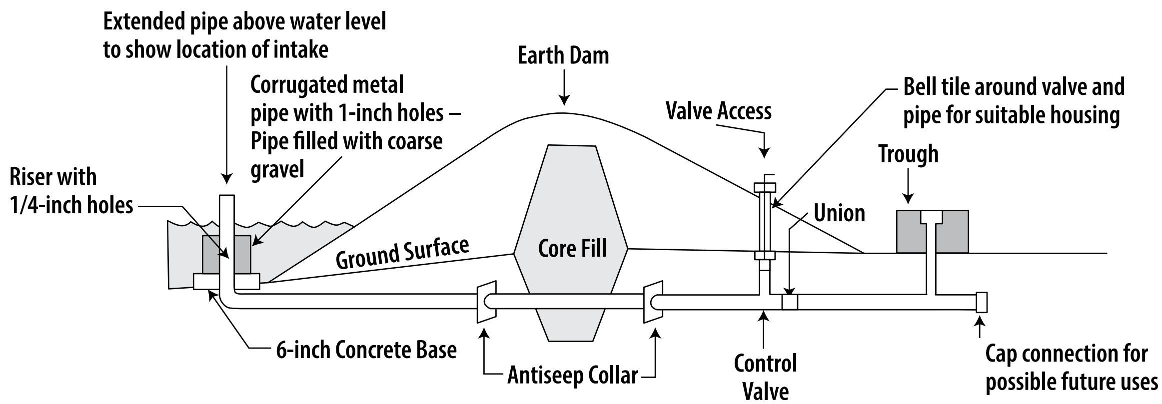
Renovating Leaky Ponds. Stone N., Southern Regional Aquaculture Center, 1999 *https://srac.tamu.edu/fact-sheets/serve/6*

Ponds — Planning, Design, Construction. Deal C. et al. Agricultural Handbook 590, USDA 1997. *https://nrcspad.sc.egov.usda.gov/DistributionCenter/pdf.aspx?productID=115* to maintain good grass cover and provides access for fire control equipment. Grazing should be done when pond banks are dry and stable.

A pipeline installed through a new or existing dam allows water to flow by gravity to a tank or waterer located below the dam. A limited access watering point allows livestock to drink directly from the pond but avoids many erosion and water quality issues with unrestricted access. Solar and animal activated pumps can be used to develop a pressurized watering system using pond water.

Pond seepage is best improved during pond construction. Even soils with adequate clay content can contain small clumps that prevent good sealing. Dispersants cause the clumps to dissolve and should be incorporated and the soil compacted into 6-inch layers during construction. When renovating an existing pond, the pond should be drained, scarified, sealed with a sealant, then compacted (Table 2). Sealing the pond after construction may not result in an acceptable improvement in sealing.





Pipe with Antiseep Collars


CAT
315C
CAT

Installing a Pipeline through a Pond Dam

This process is normally in preparation for the installation of livestock watering tanks and exclusion fences. Parts and equipment needed for installation are listed at the end of this section.

Before beginning any work, **test the depth** of the pond itself to see if it justifies the time and cost to develop the pond. **Measure the elevations** of the water surface, primary spillway, and emergency spillways. Compare those elevations with the possible site for a waterer below the pond. (A 6-foot differential is standard, but it is possible to install lines through ponds with as little as a 4-foot difference.) Finally, **locate a contractor** with proper equipment. Mini-excavators are generally not large enough to complete the installation because bottom slope of the pond is too flat. Large trackhoes are most frequently used. Backhoe tractors can also be used.

If the decision is to develop the pond, first **prepare a riser** (with holes) to be slid into the deepest part of the pond, leaving room for sediment accumulation below the lowest holes in the riser. Typically, the riser is made of the same PVC pipeline as the remainder of the pipe (1½ to 2 inch). Typically, the riser measures 6 feet, with ⅜-inch holes every 2 inches through both sides of the pipe from the top to about 2 feet from the bottom. Then the pipe can be rotated 90 degrees and another set of holes is put into the pipeline between the previous set of holes. The 2-feet-long "feet" are glued into the opposite ends on one of the PVC tees. A short piece of PVC pipe (3 inches) is glued into the third leg of the tee. The bottom end of the riser pipe can be glued into the third leg of the other PVC tee. The riser tee and the foot tee can be glued together so the riser will sit vertically; be sure to check it for close to plumb.

(NOTE: drill a ⅜-inch hole in the top of each foot to allow water to enter the riser system, without it, the pipe is difficult to sink into the water.)

Slide the riser into position with a line coming to shore where the line is to go through the pond dam. Use a two-inch "bell end" PVC pipe for this portion of the pipeline system. The final joint of pipe is ideally "gasket fit" pipe with the bell end toward the shore. These pipelines can be 40, 60 or 80 feet long to put the riser into the deepest portion of the pond. If desired, the pipeline can be floated over the trench by pulling about half the pipeline's length onto the shore and inserting the plug (tapered end of gasketed pipe with cap) and then pushing the riser back into place.

Remove the freeboard of the pond down to about 2 inches above the pond water level. The slot through the freeboard of the pond dam needs to be wide enough that the excavator can rotate without hitting any soil.

Create a trench from the shore to as far out into the pond water as the contractor can reach, plus a few feet into the dam itself. It is ideal if the trench can be 3 to 4 feet deep as it reaches the shoreline and the trench segment into the dam. The end of the trench in the dam should be as vertical as possible.

Align the pipeline and riser over the trench when the trench is clean of clods and mud. A rope or strap is placed around the pipe, so the pipe does not get lost or buried in the trench. When the pipeline aligns with the underwater trench, remove the plug from the end of the pipeline, and allow the pipeline to slowly fill with water. Replace the plug in the end of the pipeline one last time (it will be difficult to drive in as the pipeline is now full of water) and sink it into place at the bottom of the trench. A two-by-four with two 16d nails placed in one end spaced to straddle the pipeline is a good tool to guide the pipeline to the bottom and hold it in place while the contractor begins to build the seal and coffer dam.

Seal the pond. For assessing the pond materials, often the best material to initially place on the pipe in the trench is from the dam face along the shoreline of the pond. The best material is saturated and formed like modeling clay. No dry or loose material should be used in the coffer dam. The repeated process of packing and sealing the pond takes a few minutes. Do not worry about covering the entire pipeline out into the pond; the main area of concern is the area within 3 or 4 feet of the previous shoreline. Basically, the coffer dam and pipeline seal are being built in one step. Once the contractor has the seal to above the water level, the remaining water in the trench can be dipped and/or pumped out. The coffer dam construction can continue and be inspected for leaks.

Find the end of the pipeline. If well-formed saturated soils are used, the pipeline may be easily seen when the trench is pumped. If loose materials are used to build the coffer dam, construction requires a lot of manual digging because the mud seals flowing over the end of pipe must be removed from the trench. The rope on the end of the pipe is a guide to finding the pipe without damage.

Make certain the trench is sealed after finding the pipe**.** Often additional packing and sealing is needed. If the trench is sealed, the contractor can now trench the remaining distance through the pond dam. The contractor can dig the trench all the way to where the valve in the main line at the back of the pond dam is to be installed.

A section of pipeline is now assembled to the proper length and will include the shutoff valve. **Place the assembled pipeline with the valve into the trench** (with the valve in the open position). The gasket pipe joint lubricant is always recommended on the sharpened end of the pipeline. Have at least one additional person stationed to assist with pushing the pipes together, remove the plug from the pipeline through the dam with the riser (water will begin flowing) and promptly insert the pipe with the valve completely. **Now insert the pipeline with the valve into the gasket end of the riser pipe**. Allow the water to run through the pipe until it flows full. Slowly close the valve, otherwise the inertia (or water hammer) will push the gasket joints apart.

If an anti-seep collar is desired or required, it can be installed immediately behind the gasket fit junction. An alternative is to place a bed of bentonite clay under and over the pipeline for about 10 linear feet immediately after the pipe connection. Additional bentonite is added to the trench edges and bottom as the fill material is being added directly around the section of bentonite clay bedded pipe. The bentonite clay is added into the trench until the level is above primary spillway level.

If the pipeline is to be terminated at the valve, a 5- to 10-foot length of pipe should be glued onto the valve for connection later. The end of the pipeline can be capped – but not glued – to prevent dirt from getting into the line. Place a marker from the end of the pipe to the surface to mark where the end of the pipeline is located.

Place a valve protection well, similar to a meter well, over the valve to allow access from the surface. Test the valve once or twice to make sure it turns on and off completely and freely. Take care that the valve protection well is centered over the valve and in a relatively plumb position. The remainder of the trench can be re-packed, and the top of the dam reconstructed.

The process often requires about 4 hours of contractor time to complete. Typically, not more than 100 gallons of water is lost during this process.

Parts List

tee (2)

caps (4)

¼ turn valve

valve protection well casing

lid or cap for valve protection well

40-foot gasket fit pipe (2 joints, assuming 20-foot pipe sections)

(If gasket fit is not available, substitute a ¼-turn valve to replace the plug process.)

Additional Pipe

The length of pipe to be submerged in the pond water must be bell end, glue-fit pipe.

The remainder of the pipe may be bell-end, glue-fit pipe or gasket fit pipe.

CAUTION: if the pipe is purchased from a hardware store and has couplers to be glued on each end of the pipe, it may be labeled D&W (drain and waste), which is not acceptable.

Optional Materials for the Pond Sealant

8 or 10 bags of bentonite clay to use for a seal, or

anti-seep collar (1)

Equipment Needed

valve key (to turn on and off the water after the valve well is set)

drill with ⅜-inch drill bit

tape measure

permanent marker

saw to cut pipe

gasket joint pipe lubricant

PVC glue and PVC cleaner and/or primer

rope (least 10 feet long)

8-foot 2×4 with nails or screws in place to hold pipe to bottom of trench

round point shovels

transfer pump with suction and discharge hoses

container for water (to prime pump)

mud boots

extra set of clothing to wear after completing construction

Common Questions About Dry Ponds

Extended dry and drought periods offer landowners a chance to inspect the bottom of their ponds and consider cleaning out sediment or fixing a pond so it holds water better. The following questions raise important issues to think about before beginning costly renovations.

Q. How much are you willing to spend to improve the pond's usefulness?

A. Ponds are expensive, both to build and rebuild. Ponds place livestock at risk of falling through ice or getting stuck in mud while attempting to drink. Even with good construction methods, some ponds do not hold water well. Ponds require considerable ongoing maintenance. Sediment removal costs about $10 per cubic yard. The best pond maintenance practice is to fence off the pond from direct access by livestock and place a waterer below the dam to use the pond water. This minimizes damage to the dam, reduces silting into the pond, and maintains water quality. The fenced-off area and the rest of the pasture should be kept free from water-sapping trees and brush.

Q. Is it less expensive to remove sediment from the pond or build a new pond elsewhere in the pasture?

A. The "best" pond site is generally where the existing pond is located. If another suitable site is available in the pasture, it likely to be less expensive to build a new pond rather than clean the sediment from an existing pond. When comparing costs, be sure to include fencing around the pond and a below-dam watering facility in the estimate.

Q. Is the purpose of the pond to provide drinking water to livestock?

A. Many ponds were installed to provide drinking water for livestock. Other water sources may be available that offer reliable livestock water. Consider using a pressurized system from a public water supply or on-site well, or using a pond as a fenced-off water supply for a pressurized system. Compare costs for various options before beginning pond renovations.

Q. Where will the sediment removed from the pond be placed?

A. Sediment from the bottom of a pond is often sludge-like and may need time to dry before it can be used. Often, the best place to put the sediment is on the back side of the dam. Other potential uses include filling nearby gullies and ruts. To avoid livestock from getting stuck, a temporary electric fence can keep livestock out of the deposited sediment until it dries. Avoid placing sediment near or upslope of the pond because it will wash back into the pond.

Q. Can the sediment be used as a building or topsoil material?

A. Pond sediment has little soil strength, making it unsuitable for use around or under a foundation. It can possibly be used to fill in eroded sites.

Q. Is the pond located on a site that will hold water?

A. Ponds that hold water are built on sites with appropriate soil texture (percentages of sand/silt/clay). Clay content is especially important for the pond to seal correctly. A core trench is an essential component of the dam construction for the pond to seal well. The core trench is constructed early in the pond installation process. The trench is constructed by removing soil from the ground under where the dam will be placed until a good clay soil layer is encountered. Most core trenches are at least 4 feet deep. Clay soil is added back into the trench and packed down, preventing water from seeping under the dam after it is constructed. The lack of a core trench is one of the major reasons ponds leak. When a rock layer is encountered during pond construction, 6 inches or more of a high-clay content materials must pad the rock.

Q. Does the soil at the pond site contain enough clay to seal well?

A. You can check the clay content by performing a ribbon test. Pick up a small handful of soil (the sample), wet it with water, and squeeze into a ball. Squeeze the soil through your fingers, rubbing your forefinger against your thumb. The soil should begin to form a ribbon. Do this several times with different samples. A soil with as little as 20% clay will form a 2-inch ribbon.

https://www.youtube.com/watch?v=GLKSxRK2zz0

https://youtu.be/IOyaBxj767s

Measure the length of the ribbon and think about the feel of the soil. Gritty soil that produces a short ribbon may not seal correctly. Smooth textured soils, especially those that produce a ribbon longer than 2 inches, are more likely to seal correctly.

Q. Can pond seepage losses be reduced?

A. Pond seepage is best improved during pond construction. Even soils with adequate clay content can contain small clumps that prevent good sealing (Table 3). Dispersants cause the clumps to dissolve and should be incorporated and compacted into 6-inch layers during construction. When renovating an existing pond, the pond should be drained, scarified, sealed with a sealant, then compacted. Sealing the pond after construction may not result in an acceptable improvement in sealing.

Q. How compacted should a pond dam be?

A. Check compaction using a soil penetrometer, driving it into the soil at a rate of 1 inch per second. Compaction should be 625 pounds per square inch or more. For large dams, a hydraulic conductivity test may be necessary, send soil samples to a commercial lab to see how fast water can pass through the compacted soil.

Table 3. *Application Rates*

Material	Application rate (pounds per 100 sq. feet)	Notes
Bentonite	100 to 150 (silty soils) 200 to 300 (sandier soils)	Most expensive.
Soda Ash	10 to 25	Makes a good seal. Soil must contain >15% clay + 50% clay/silt soil.
Rock Salt	20 to 33	Least expensive. Application during new construction is unlikely to harm fish.

For more information on pond sealing:
https://extension.missouri.edu/publications/g1555
https://srac.tamu.edu/fact-sheets/serve/6
https://nrcspad.sc.egov.usda.gov/DistributionCenter/pdf.aspx?productID=115

Spring Development

Overview

Spring developments collect and use water from a flow at or near the ground surface. Compared to a pond or well, a spring development can be an inexpensive source of livestock water.

Advantages

- Improved water quality for livestock.
- Relatively inexpensive.
- Small flows can be developed into a valuable water supply.
- Spring water is warmer during the winter than surface water, reducing the need to break ice for livestock drinking.
- Can often use gravity flow to move water into a tank.
- May be possible to develop with on-farm supplies and equipment.

Limitations

- Springs occur naturally and only in some areas.
- A small spring may require a storage tank to maintain a reliable, adequate supply of water.
- Supplemental power is required if water is to be pumped uphill.
- Fencing may be needed to protect the spring from livestock trampling and manure deposits.
- Site-specific design, planning, and construction are required.
- Spring flow may decline or stop during drought.

Design Considerations

At a minimum, a spring should have a year-round flow rate of at least 1 gallon a minute. With proper storage, this minimum flow can water nearly 100 cattle. Before investing in development, a spring should be monitored to make sure adequate flow is maintained throughout the year. Neighbors or previous owners can be consulted about a spring's dependability as a water source.

The flow rate of a spring can be tested by digging a 5-gallon bucket into the slope below the spring and allowing the water to flow into the bucket. Determine the flow rate by timing how long it takes the water to fill the bucket.

While year-round springs are preferred, wet-weather springs may be an adequate water source if the pasture is only grazed from May to early July. Wet-weather springs may not be an adequate source during typically hot, dry weather in July and August when livestock demand and evaporation rates are high. Wet-weather springs may be adequate for winter grazing.

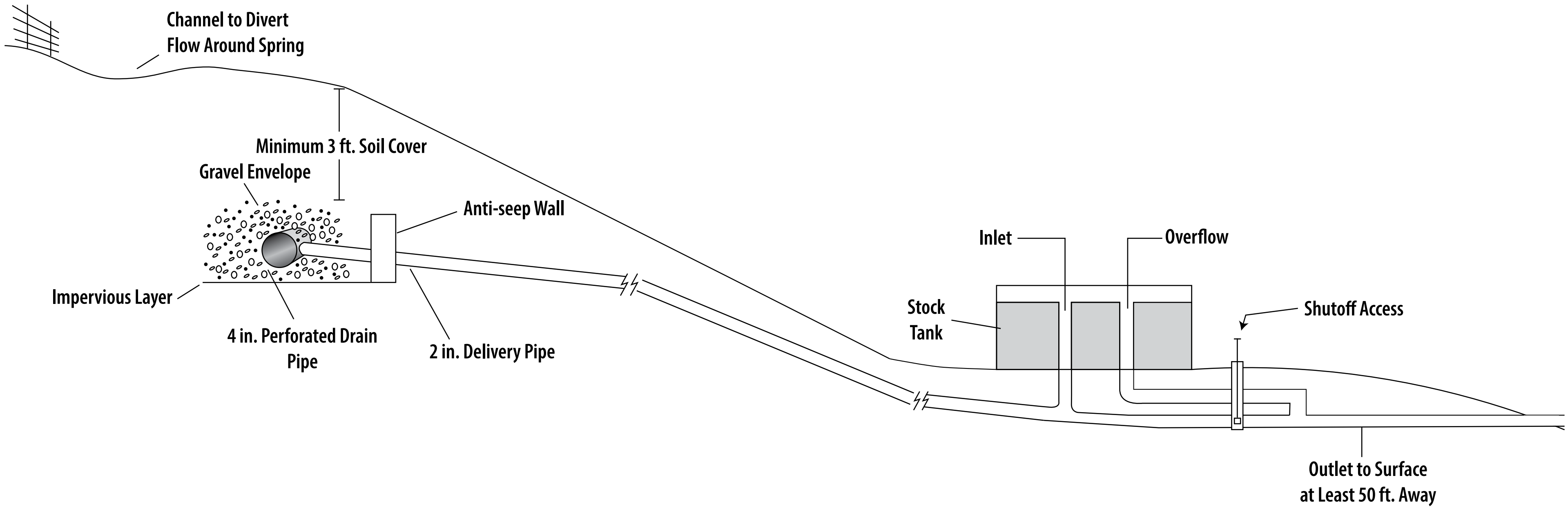
Spring water quality and quantity can be protected and enhanced by good management around the site. While total water flow cannot be increased, removing cattails, shrubs, and trees will direct more of the spring flow into the livestock watering system. Fencing livestock away from the seepage area or installing underground collection tile will help protect the quality of spring water. Surface runoff should be diverted around the spring by shaping the ground.

If an underground collection trench is used, a backhoe can be used to dig out the collection trench. A plastic membrane can be used to funnel underground seepage into perforated drainage pipe, usually 3-inch or larger diameter. This pipe should be surrounded by a fabric filter and washed rock. The collection trench should be covered with clay and mounded to divert runoff and prevent surface water infiltration.

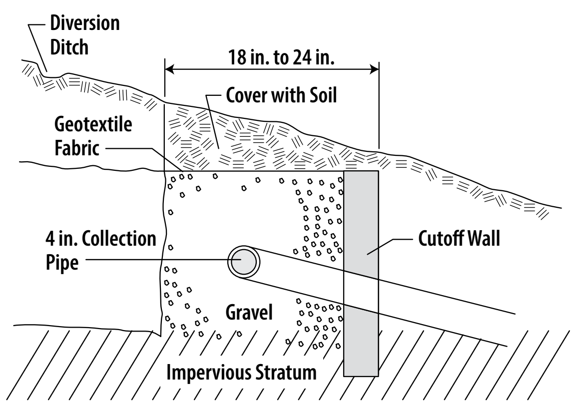
If the spring development is on a slope or ridge, water can be piped downhill to a storage tank or livestock watering tanks, possibly serving multiple pastures.

Contact your local NRCS for technical assistance in designing a spring development to ensure a low-maintenance and dependable watering system.

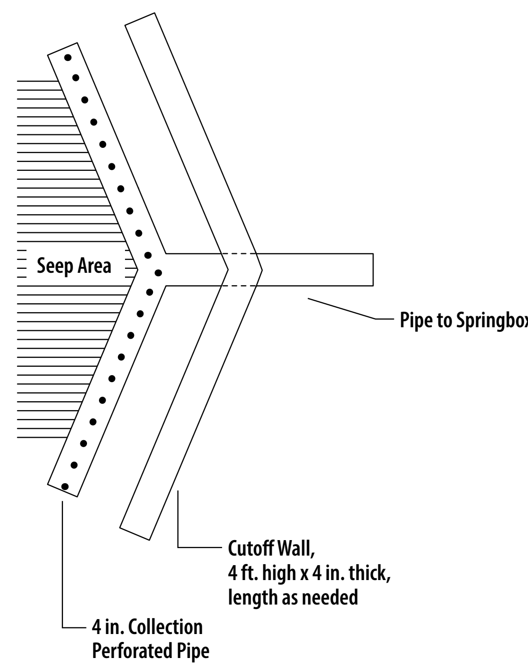
This practice may require permits. Please read the *Permits in Kansas* chapter of this handbook.



2b. Concentrated Spring (cross section)



Low-area Spring (aerial view)



Stream

Overview

Small streams are a common source of livestock water in Kansas. Where livestock have direct access to the stream, restricting access can reduce bank erosion and livestock injury while improving the reliability of water flow and water quality.

Advantages

- Naturally occurring, no direct installation cost.
- Water normally clean and fresh.
- Hardened surface access points can minimize livestock impacts and provide a vehicle crossing point.
- No mechanical or electrical parts to fail.

Limitations

- Livestock may increase bank erosion.
- Potential injury to livestock slipping on banks or getting caught in tree roots.
- Needs regular repairs to water gaps after floods.
- Riparian area around stream may be overused by livestock.
- Stream may not be optimally located, resulting in poor grazing patterns.
- Seasonal flow rates may fluctuate or have no flow during dry periods.
- Stagnant pools with poor water quality may develop during periods of low water flow.
- Potential increases in levels of fecal and other bacteria in the stream.

Design Considerations

Restricting access to specific points along a stream is recommended to eliminate most bank erosion caused by livestock traffic as well as potential livestock injuries. Access ramps or trails with hardened surfaces such as coarse gravel over geotextile and slopes of 6:1 or flatter allow easy access to the stream. Locate shade, salt, minerals, and winter feeding sites away from the stream to reduce overuse of the riparian area.

Refer to the “Limited Access” chapter for additional design information.

This practice may require permits. Please read the “Permits in Kansas” section of this handbook.


TREGO RWD 2

Rural Water District — Public Water Supply

Overview

Rural water districts deliver water to rural areas and small communities not served by municipal water systems. These districts deliver a reliable source of water that meets the US Environmental Protection Agency's drinking water standards. Water supplied by rural water districts can be used as a pressurized livestock water source.

Advantages

- Reliable with few interruptions or outages.
- Higher-quality water than may otherwise be available for livestock use.
- Water system maintenance is not the user's responsibility.
- Water is already pressurized.

Disadvantages

- May not be available in a location where livestock water is needed.
- Cost to extend a service line for livestock water use may be prohibitive.
- Long privately installed lines may be necessary to deliver water to desired location from the rural water system pipeline.
- May be more expensive than other livestock water sources.
- Rural water district may not have capacity to add additional users.

Design Considerations

Rural water districts typically require an application and have a connection fee. This fee is usually modest when the district is in the planning stages. Once the district has installed water lines, the fee may increase. Grants and low-interest loans are often used to offset some of the costs of establishing a rural water district, but these cost offset measures are generally not available after the district has been set up for expanding the water distribution system. A new user may need to pay for the total cost of an extension water line to connect to the district. Water districts may not seek to expand their systems due to district finances and the ability to supply additional water.

A rural water district charges a minimum monthly fee that covers a specific amount of water use. If livestock only use rural water during part of the year, the monthly cost must continue to be paid even if the water is not used. Additional charges are levied for water used in excess of the specified amount included in the monthly fee. This is an incentive to conserve water.

Hauled Water

Overview

In some situations, hauling water may be more economical or feasible than trying to develop a permanent supply for livestock drinking water. Situations where permanent water systems are impractical can include watering a small herd, a site with an insufficient or no water source, or a site where electric power is unavailable. Hauling water may allow use of short-season or supplement forages and small or remote sites.

Advantages

- Highly mobile; water can be supplied to any location that can be accessed by the hauling vehicle.
- Can supply multiple sites.
- Ability to move watering locations, to improve pasture management, allow adjustments for additional livestock or pastures, and result in fewer livestock trails.
- Can be used where the cost of developing a permanent water source is prohibitive.
- Allows short-term grazing of temporary forage supplies, such as crop residue or cover crops.
- Can be used during drought when other water sources dry up.

Limitations

- A hauling tank and a vehicle are both needed.
- Muddy, freezing, or snowy conditions can complicate or prohibit water delivery.
- Hauling water is labor and time intensive compared to the operation of other watering sources. The operator must wait for the tank to fill and unload in addition to hauling time.
- Motor fuel, equipment, and water costs directly affect the cost of hauling water.
- Hauling may be required daily or multiple times a day.
- May need to construct access roads to reach tanks.

Design Considerations

A water-hauling tank should be clean and completely enclosed. Transport tanks, pumps, and hoses should be free from agricultural chemical contamination. Small amounts of these chemicals may cause severe side effects or death of livestock.

The tank can be incorporated into the vehicle, such as a repurposed milk truck. A tank can be placed in the back of a truck and removed when the vehicle is needed for other purposes. Tanks can be placed on trailers, or existing tank trailers such as old anhydrous tanks can be adapted for hauling water. Interior baffles improve vehicle handling. Do not exceed weight limits on bridges; select an alternate route if necessary. Drive smoothly around turns and when accelerating and decelerating to maintain a stable center of gravity.

The tank will need to be manually hooked up to and disconnected from a water supply. A float can be installed to shut off the water supply when the tank is full, preventing overflows. Shut-off valves and hoses may be used to regulate water dispensing. In some cases, water-transfer pumps may be required.

When stock tank storage is insufficient, or water will freeze quickly, multiple deliveries may be needed each day. Evaluate the cost of water, travel time and distance to and from the delivery site, and fill time when selecting a filling site.

Drilled Well

Overview

In areas where groundwater is available, a drilled well can be the preferred source of reliable, high-quality water. About 50% of Kansas is covered by aquifers that reliably yield enough water to supply a well. Where major aquifers are not found, small local aquifers may provide adequate water for a low-output well.

Advantages

- No evaporation or seepage losses.
- Soil provides good protection from surface water contamination.
- May be located near where water is needed.
- Not subject to freezing.
- Water quality is usually consistent; changes in quality tend to occur slowly.
- Has a long, useful life, especially when properly maintained and protected.

Limitations

- Extended drought may result in lower water levels and discharge rates, or the well going dry.
- In some areas, groundwater is located quite deep, making the well prohibitively expensive.
- Deep wells may have brackish water in many areas of Kansas.
- Test holes, abandoned wells, or careless surface activities have polluted groundwater in some areas.
- Groundwater is constantly moving through the aquifer, causing changes in water quality.
- Much of east-central and southern Kansas lacks groundwater aquifers.

Design Consideration

Kansas well drillers are licensed by Kansas Department of Health and Environment and must use well components that meet state construction standards.

Wells should be located upslope and away from contamination sources and activities that may affect water quality. Slope the ground surface away from the well to prevent water from ponding within 50 feet of the well. The slope should be at least 6 inches in the first 20 feet from the well to ensure drainage. Fencing or a managed area around the well can offer protection from careless actions or contaminants that might harm the water quality.

A watertight casing should extend at least 1 foot above the ground, and the casing should be tightly capped or plugged with a sanitary seal to prevent the entry of surface water that may contain pollutants. A screened vent installed in the cap allows air movement into the well, preventing casing collapse.

If the site is prone to flooding, the casing should extend 1 foot above the highest expected flood level. The casing must be watertight its entire length from the top of the casing to the water intake screen below the water table. No holes are allowed in the casing except for an approved pitless adapter, which must be sealed to the casing.

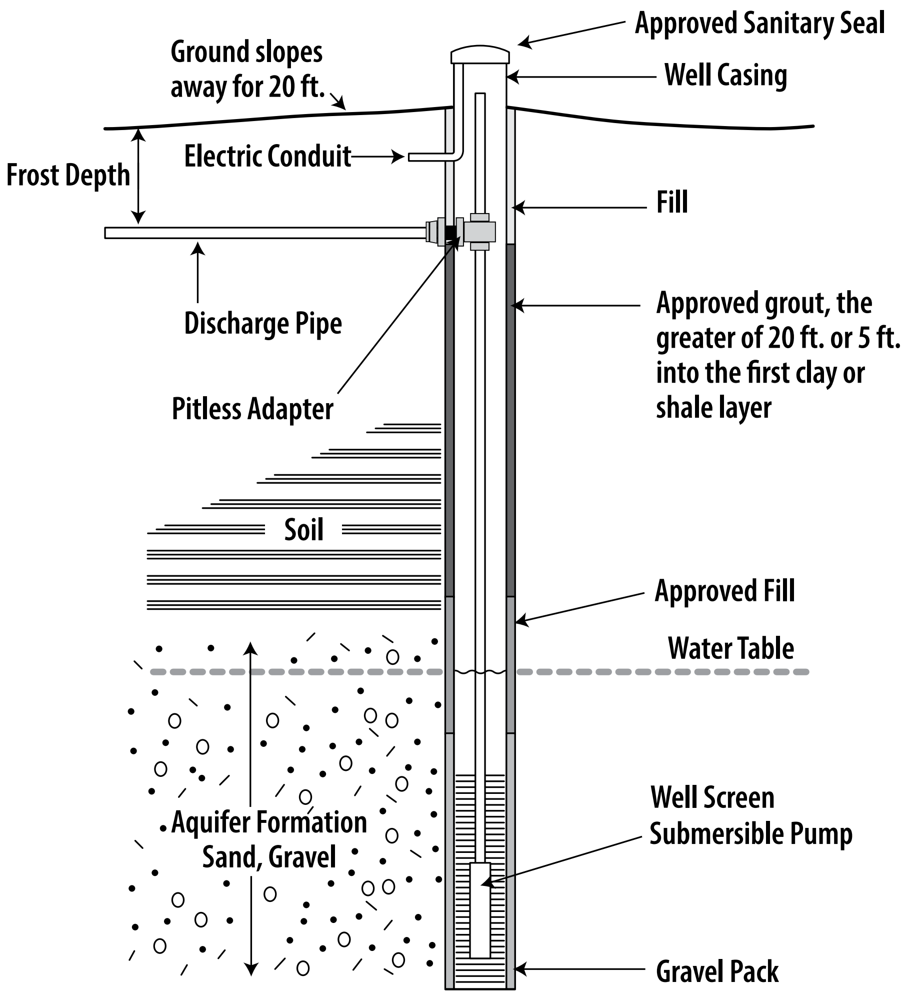
An approved grout is used to seal between the borehole and the casing from the surface to 5 feet into the first clay or shale confining layer or 20 feet below the surface, whichever is greater. The grout must be placed adjacent to all confining layers to separate water bearing layers. Bentonite clay, neat cement, and cement-water slurries are all approved grouts.

An approved pitless adapter is installed where a subsurface pipe joins the well casing when there is no well house, enabling a water-tight connection below frost level.

Maintenance is essential to ensure the well continues to meet all location and construction standards. Components should be check annually and cleaned and disinfected after inspection or anytime the well casing is opened (see K-State Research and Extension publication, *Shock Chlorination for Private Water Systems*, MF911). Test the water after maintenance activities to confirm the water remains uncontaminated.

Well drilling is regulated by KDHE Bureau of Water Geology section. Wells should be drilled by a licensed waterwell contractor abiding by state waterwell regulations. Some counties or regional jurisdictions may have additional well drilling regulations and may require permits. State law requires that abandoned water wells should be plugged.

This practice may require permits. Please read the permit section of this handbook.



Intake Structures for Ponds and Streams — Wet Well

Overview

Ponds and streams can serve as sources of water in areas where drilled wells are unlikely to provide adequate water or are too expensive. A wet well is a water collection system with a filtered water pipeline inlet from the stream or pond into a below-ground water storage structure. A pump placed in the wet well sump distributes water through a pipeline to livestock drinking devices. Positioning the wet well alongside a stream rather than in the stream bed protects the pump and inlet from damage during flood events and avoids plugging. A wet well can be a reliable source of water during periods of fluctuating water levels.

Advantages

- Reduced bank erosion.
- Reduced livestock impact on water quality compared to direct access.
- Improved quality of water provided to livestock.
- Pond or stream usefulness extended due to less trampling.
- Reduced pump site maintenance and possibility of increased pump life.
- Performs well throughout a wide range of water levels.

Limitations

- Construction equipment may be necessary for installation.
- Few examples in Kansas to use as references.
- Excavation is required below ground level; rock layers could restrict wet well location.
- Usually requires a pump and power supply.

Design Considerations

A backhoe or excavator is used to construct the wet well by digging a well hole, deeper than the stream or pond, more than 20 feet from the water's edge. A perforated culvert tube or large diameter well casing is placed in the hole. The casing size is determined by the flow rate of the stream, the desired pumping rate, and the type of pump that will be used. The minimum casing is typically between 6 to 8 inches in diameter. Clean gravel is installed around the base and sides of the casing to fill the hole.

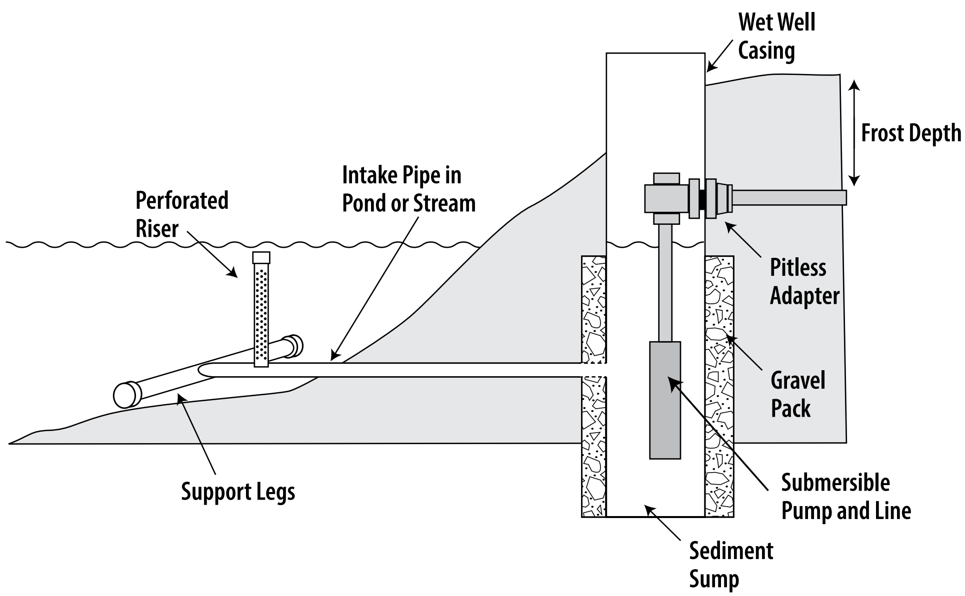
Following construction of the well, the intake line is installed to allow water to flow from the stream or pond into the well. A trench is dug between the bottom of the stream or pond to the well casing. The depth of the trench should be level with or below the bottom of the water source. Coarse sand or river gravel filter media or plastic/PVC pipe is installed in the trench to transport water from the source to the well. A large basin around the well casing filled with a clean, uniform gravel serves as a reservoir for storing water near the casing.

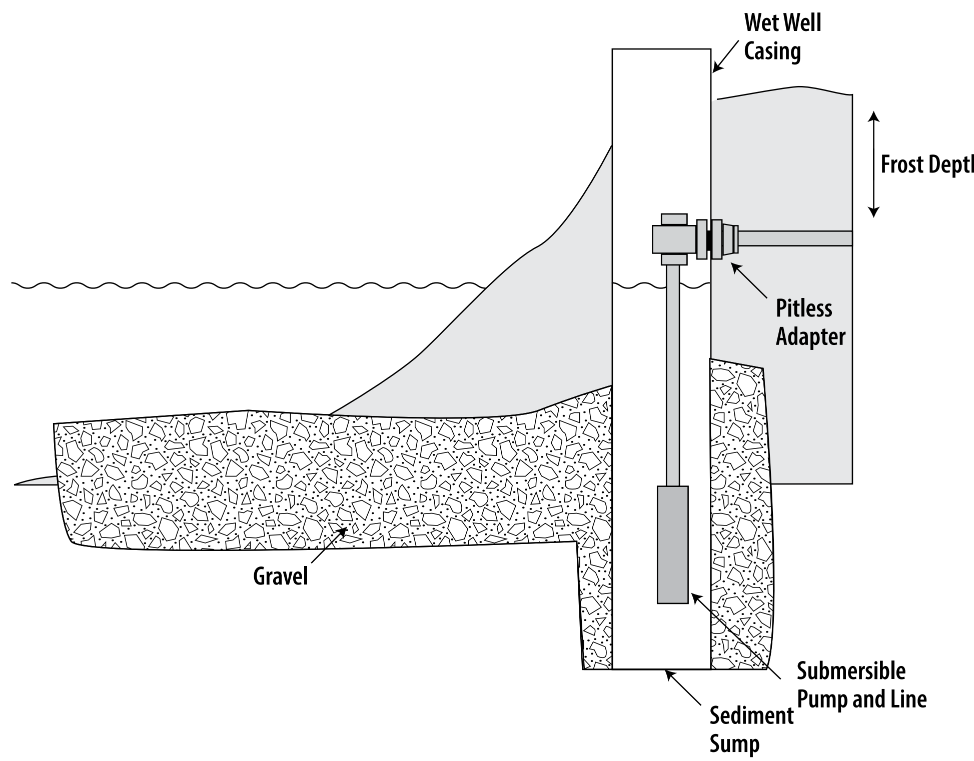
When using gravel filtering media, the life of the media can be extended by installing a filter-fabric barrier between the gravel and the soil layer filling the trench. The filter fabric barrier prevents fines from accumulating in the filter rock and will extend the life of the media.

To reduce future maintenance problems, a pitless adapter can be placed in the side of the casing where the water system line leaves the well casing. Pitless adapters serve as a disconnect between the vertical discharge pipe coming from the pump and the horizontal pipeline going to the supply line and adapters should be located below the frost level.

Once all the lines and/or media are installed, soil on the surface can be replaced and reshaped. Soil can be replaced over and around the wet well. Raising the soil level around the wet well diverts surface water intrusion.

This practice may require permits. Please read the permit section of this handbook. Abandoned water wells should be plugged.


Wet Well
Casing
Frost Depth
Intake Pipe in
Pond or Stream
Perforated
Riser
Pitless
Adapter
Gravel
Pack
Support Legs
Submersible
Pump and Line
Sediment
Sump


Wet Well
Casing
Frost Depth
Pitless
Adapter
Gravel
Submersible
Pump and Line
Sediment
Sump

Pumps, Pipelines, and Storage

Pump Comparison Chart

Power Type	Primary Advantages	Primary Limitations	Initial Cost	Maintenance Cost
Electric – Solar/DC Power	• Long useful life. • Low maintenance costs. • Free energy.	• Expensive initial cost. • Needs to be coupled with water storage.	\$\$-\$\$\$	\$
Electric – AC	• Continuous power to pump. • Low operational costs.	• Must be within reasonable distance of electric grid. • Initial cost of meter and electrical line installation to site can be expensive.	\$	\$
Air	• Simple technology. • Long life, low maintenance. • Free energy.	• Dependent upon wind. • Needs to be coupled with water storage.	\$\$	\$
Gravity	• Free energy. • Inexpensive. • Dependable.	• Low pressure. • Not suitable to all locations. • Advance planning necessary when installing in new pond.	\$\$	\$
Wind	• Free energy. • Long life. • Adapted to remote locations.	• Dependent upon wind. • Needs to be coupled with water storage.	\$\$	\$
Animal	• Simple, rugged, portable. • Use with ponds, streams, shallow wells. • Inexpensive.	• One unit required for every 25 cattle. • Will draw water about 20 feet vertically or 200 feet horizontally. • Labor intensive maintenance.	\$	\$\$
Water	• Inexpensive. • Free energy. • Low maintenance.	• Requires year-round surface water flow. • Limited output. • May not work well in winter.	\$	\$

Pump Types

Overview

Pumps are the most common and inexpensive way to lift, move, and pressurize water. Pumps lift water from water sources to storage tanks at higher elevations and pressurize water systems to deliver water to the place where livestock will use it.

Advantages

- Modest initial cost and reasonably long life.
- Require little maintenance except for piston or reciprocating pumps.
- Simple and easy to understand how to use.
- Pumps located above ground can easily be replaced with available tools.
- Powered by electric motors or gas engines.
- Available in a wide range of sizes and manufacturers.
- Electrical pumps are easily automated, even at remote sites.

Limitations

- Desired flow and pressure rates determine the type of pump needed.
- Pumps incorrectly matched to the application may be inefficient or fail to work.
- Engine-powered pumps must be checked daily.
- A controller specific to the application is needed to operate an electric pump.
- When extracting a pump installed in a deep well for maintenance, special equipment may be required.

Design Considerations

The two broad classes of water pumps are centrifugal (turbine) and positive displacement. Air-lift pumps are a third type of pump that uses compressed air. Each type of pump has specific properties that make it best suited for a specific set of conditions.

Centrifugal pumps are not complicated, operate smoothly, are efficient, affordable, and have a long life. Centrifugal pumps have large impellers that spin to move water by suction and are not powerful enough for most wells. Centrifugal pumps are commonly used to move or pressurize water from shallow wells (less than 24 feet to water) and are installed above ground. To avoid the need to prime the pump with each use, a check valve is essential.

Jet and deep well jet pumps are generally used in shallow wells with static water levels greater than 25 feet. A jet pump consists of a centrifugal pump with a jet assembly inside the well to create a low-pressure zone that lifts water from the well. With the jet, water can be lifted about 100 feet. The greater the lift to the pump intake, the more water is required to power the jet, reducing the discharge rate. While jet pumps are considered less efficient, they are generally adequate for intermittent livestock watering. All major parts of a jet pump are at the surface, facilitating maintenance, but require a pump house to avoid freezing. This style pump is frequently upgraded to a submersible centrifugal pump when replacement is needed (eliminating priming issues).

Submersible turbine pumps are efficient, have a long life, low operating costs, and are frequently used in small water wells. Designs are available for a wide range of flow and pressure applications. The pump has small impellers that easily fit inside the well casing. Each impeller has limited pressure and flow capacity. By using multiple impellers in series along a common shaft, sufficient head pressure is developed. Submersible pumps are constructed with the motor at the bottom, impellers and discharge at the top, and the intake located between the motor and impellers. Waterproof wires deliver electricity down inside the well casing to power the motor.

Diaphragm (positive displacement) pumps are simple in design. They are often paired with a solar power supply. An off-center cam or knob on top of the drive shaft moves a diaphragm up and down to produce a pulsating discharge. A check valve on the intake side of the pump allows water to enter the pump but not to flow backwards. A second check valve on the outlet side allows water to exit the pump but not reenter. Submersible diaphragm pumps can raise water as much as 200 feet. Diaphragm pumps placed on the surface are limited in their lift but can generate adequate pressure for use with livestock watering.

Piston and reciprocating pumps use a piston or plunger that produces a pulsating discharge. Windmills most often use a piston pump that is in the water below the rotor. Check valves located on the intake and piston keep water from flowing backward. Piston pumps are easily adapted to hand- or machine-powered operation. Continuous flow pumps are well suited to pairing with electrical power and have often replaced piston pumps. In remote locations where electricity is not available, the continuous flow pump is still used with windmills, as it was used historically. Maintenance of moving parts is relatively greater for piston pumps. Reciprocating pumps are usually paired with an electric or gasoline motor and can be used for very high lifts.

Helical pumps are comprised of only two parts: a rotor inside a rubber stator (sleeve). As the corkscrew rotor turns, it forms cavities within the stator that move the water through the pump. Suitable for deep wells, helical pumps can move relatively small amounts of water to very high heads. Helical pumps are easily damaged by sand or other debris. Repairs are relatively easy and inexpensive. These helical pumps can create higher heads than most other pump systems.

Variable speed pumps or variable frequency drives (VFD) have a control box on the motor that reduces the number of times the pump cycles by adjusting the motor speed to meet the current water need rather than maximize water production. Reducing frequent start/stop cycles can lengthen the life of a pump motor. The variable frequency drive allows use of a smaller pressure tank. A pressure sensor mounted on the pump outlet measures water pipeline pressure and communicates with the variable frequency drives to adjust the motor speed to keep water pressure constant as the rate of water draining from the system varies. At usage rates of less than 1 gallon per minute, the pump shuts off until water pressure drops and the variable frequency drives restarts the pump. Most variable frequency drive systems include a “soft start” feature that allows 2 to 3 seconds for the pump to start, rather than the standard pressure switch-activated motor which restarts within a fraction of a second.

Solar-Powered Pumping Systems

Overview

Solar-powered pumping systems provide dependable, low-maintenance watering systems in remote locations and are widely used for livestock watering applications with both well and surface water sources. The cost of a solar pumping system is often less than the cost of bringing an electrical service line to the pump location. Maintenance costs are lower than for windmills. Solar pumping systems are especially useful for temporary water delivery in rotational, crop residue, and cover crop grazing situations.

Advantages

- Compatible with a wide variety of pumps to meet various water pressure and flow rate needs.
- Allows livestock access to drink water away from a stream or pond.
- Long useful life with low operating costs.
- Pump can be replaced by the producer.

Limitations

- Provide intermittent power supply.
- Affected by short winter daylight hours, tree shadows, and cloudy conditions.
- Requires a multimeter to troubleshoot problems.
- Components may not be available at local hardware store, may need to order from specialty supply stores or online.

Design Considerations

Solar pumping systems are powered by sunlight, which is converted to electrical power using photovoltaic panels. Sunshine works well as a power source for livestock watering because the days and times with the greatest solar energy typically coincide with the periods of greatest livestock water demand.

A solar pumping system is comprised of solar panels, a pump (often with a controller), and a storage tank or livestock watering tank. Batteries may be needed to store energy for nighttime or cloudy-weather pumping.

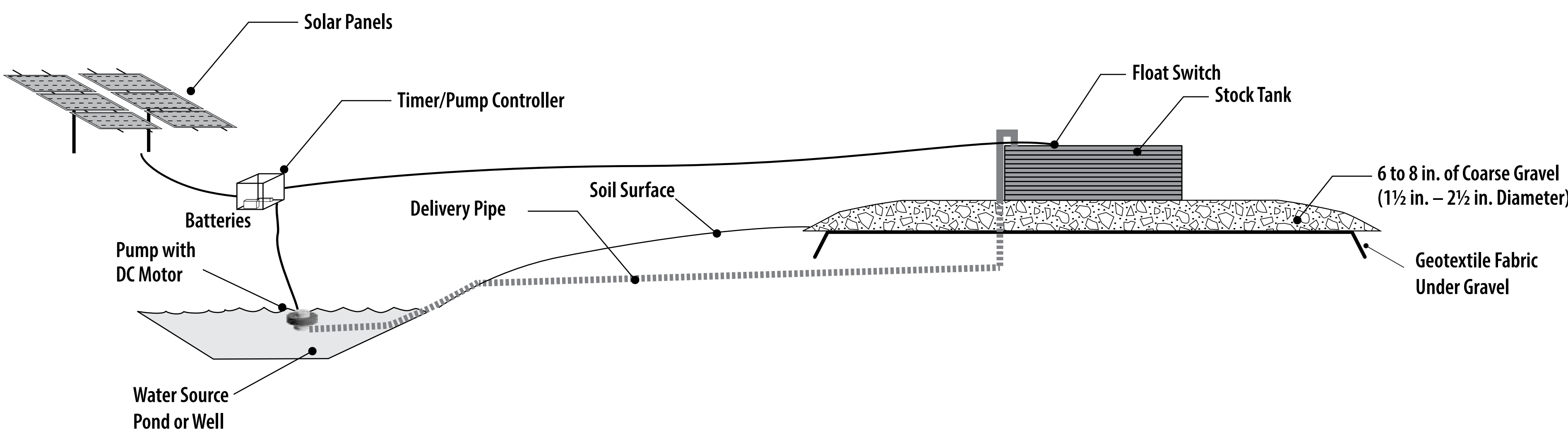
A photovoltaic solar panel converts sunlight to DC electrical power. The size of the panels must match the power requirements of the pump. High lift (deep) wells and higher water pump volumes increase the power requirements (more watt and/or more volts). Solar panels cost about $1 to $2 per watt. Panels have a long life and may have up to a 25-year warranty.

Trackers improve pumping by about 30% to 40% over the course of a summer, possibly allowing a design with fewer panels. For some solar systems, installing additional panels is likely more cost effective than using a tracker. Active trackers powered by electricity being produced by the panels rotate the panels to follow the sun from east to west during the day, increasing power production efficiency. Passive trackers use the sun's heat to move a liquid from side to side, and gravity moves the panel.

A controller optimizes the variable energy from the solar panel to improve pump performance in low light conditions. Other solar pumping system controls include pump speed, tank water level, low water cutoff (to avoid running the pump when the well is dry), an on/off switch, and indicator lights. Controllers should be sized for voltage and amperage needs of the pump and solar panel.

The pump moves water from the source to the delivery point using the DC power produced by the solar panels. Each additional foot of head the water is lifted requires greater watts of power from the panel. Diaphragm pumps are often used in solar systems with well depths of 100 to 200 feet depending on the water volume delivery requirements. Helical pumps use a screw rotor inside a rubber sleeve to push the water. Helical pumps work well with solar systems, moving water to greater heights or in greater volume than diaphragm pumps. Centrifugal pumps' pressure (or head) capacity can be increased by stacking additional impellers within the pump.

Cloudy days, nighttime, and other times when the solar panels aren't producing electricity can be mitigated two ways. A water storage tank or cistern provides several advantages. Storing water, rather than electricity in batteries, is often less expensive and more efficient and reliable. A storage tank should hold a minimum of a three-day water supply. Batteries add cost to the system (as do storage tanks) but batteries can have more maintenance problems.



The combined cost of the solar components as described above would be about $2,500 and would have the capacity to pump 75 feet of head with a flow rate of 3 gallons per minute.

Surface water pumping systems move water from shallow wells, streams, or ponds to livestock watering tanks. Surface water systems are assembled using solar panels, charge controllers, float switches, relays, and pumps and may not require expensive pump control circuitry. Low-cost, portable 12-volt systems often require a battery wired into the system to provide the amperage necessary for the pump. The charge controller prevents the solar panel(s) from excessive battery charging and discharging. The relay allows a high-current pump to be turned on and off by a float or other switch mechanism which can only handle a low amount of current. When greater volume or lift is required, a 24-volt system can be used.

Surface water systems may use diaphragm (ATV sprayer pumps) and centrifugal pumps (12-volt sump pumps). There are a variety of submersible diaphragm, centrifugal and helical pumps available from U.S. and foreign sources online. These pumps are usually reliable but not as well-known as those from more prominent brands.

Wind-Powered Systems

Air lift pumps have low maintenance costs, a long life, and no rotating parts. Compressed air is forced through a small-diameter pipeline that extends below the water line, then the pipeline delivers air through a nozzle into the well water under the lower end of the delivery pipe. An open-ended delivery pipe extends upright from below the water level to a discharge pipe above ground. As the air bubbles move upward, water froth is created and moves up through the delivery pipe. Water is delivered in pulses and the pump is best suited for pumping into an open-topped water tank. Do not use air lift pumps in pressurized water systems. Air lift pumps are relatively inefficient in moving water but can be sited anywhere a wind-powered air pump or other compressed air is available, up to a quarter mile from the delivery point. The pump must be placed deep in the well for it to work. Neither the pump nor any of the pump components are damaged during operation without water.

Windmills are comprised of both the windmill head, the tower on which the windmill is supported, and the plunger-type pump driven by the rotation of the windmill head. Windmills are commonly found in grassland areas of Kansas and are suited to remote locations where other power sources are unavailable.

Advantages

- Abundant, free energy source.
- Well-suited to locations where electricity is unavailable.
- Long, useful life.
- Mechanically simple.

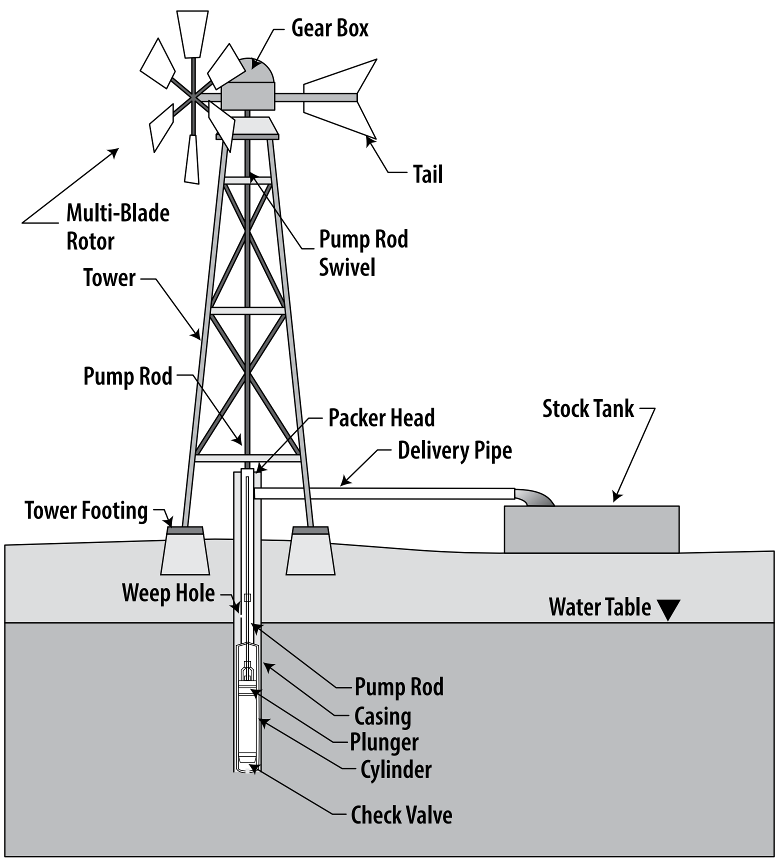
Limitations

- Depend on wind blowing, and need large tank or storage tank for when the wind doesn't blow.
- Maintenance of the windmill head must be done while on top of the tower.
- Contractor may be needed to do maintenance.
- High initial cost.
- Subject to damage in high-wind conditions and severe thunderstorms.

Design Considerations

Windmills should be sited at least 75 feet away from trees or buildings that alter or slow wind currents.

The size of the windmill head should be based on the depth of the well and the size of the pump. Windmill heads range in size from about 6 feet to 20 feet. Larger-size windmill heads are used with deeper wells or a need for higher rate of water delivery. Windmills can lift water 800 feet. The windmill head swivels on the tower to face into the wind

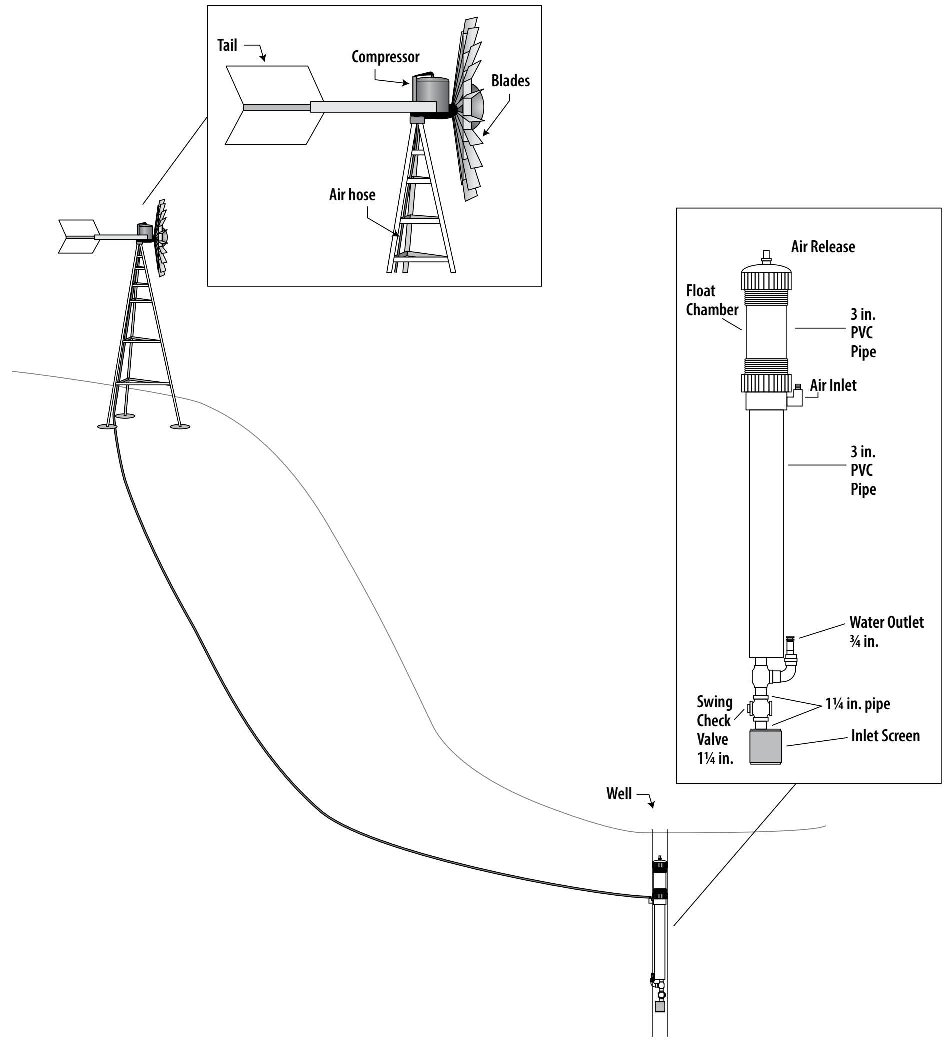


using a vane attached to the back side of the head. The head is awkward to handle because of its size and weight.

Windmill heads can be installed on new or reused towers. Towers typically have a metal ladder attached to the side of the tower to facilitate routine maintenance. A windmill brake is used to stop the windmill from turning while being serviced or when water is not needed. Windmill heads should have the gearbox oil level checked twice per year, and oil should be replaced when it becomes dirty. Insufficient or dirty oil will accelerate gear wear. Fan blades should be checked and replaced if necessary.

Pump leathers can last about five years and do not require ascending the tower to be replaced. Sand in the water will decrease the life of the leathers.

Contractors are often hired to handle windmill repair and maintenance services. Consider the contractor's cost and travel distance when contemplating installing a windmill.



Gravity-Powered Systems

Overview

There are two forms of gravity-powered systems: gravity flow and siphon.

Gravity flow uses elevation differences to move water from a higher elevation, such as a storage tank, to a lower elevation, such as a watering tank. A pond or storage tank with a pipe or hose extending to a tank located at a lower elevation uses gravity to transfer water as long as all components are below the water source. Water can be moved to a higher elevation using a pump.

A siphon system allows water to flow to a higher elevation than the water surface with the final elevation below the water source. The tube or hose cannot contain any air voids. A simple siphon system may consist of two adjacent water tanks connected by a U-shaped hose over the upper edges of the tank. A pond that has a tube with one end in the pond and the tube goes up and over the dam and down into a tank located below the dam is a siphon system.

It is common for an air trap to accumulate at the high point of the siphon system, causing the flow to stop. The producer will need to be prepared to "restart" the siphon when this occurs.

Gravity-powered systems for livestock most often have a valve and float system to control the water level in the tank. Otherwise, water in gravity-powered systems will flow until source and tank have identical water levels.

Advantages — Gravity Flow

- No power required to operate.
- Relatively inexpensive.
- Gravity flow is dependable.

Limitations — Gravity Flow

- Relatively low pressure.
- Requires planning to get system installed during construction.

Advantages — Siphon

- No power required to operate.
- Relatively inexpensive.
- Serves well in emergency situations.

Limitations — Siphon

- Periodic repriming will be required.
- Lack of assurance the system is working.
- Temporary system that requires labor each time to set it up, including temporary tanks.

Design Considerations

Most gravity-powered systems operate on low pressure. One foot of elevation can provide 0.43 pounds per square inch. The system requires 2.31 feet of head to equal 1 pound per square inch, (6 feet of head is only 2.59 pounds per square inch). Friction line losses can become significant with such low pressures.

For livestock watering using gravity-powered systems, a 6-foot head is normally the minimum recommendation to ensure a sufficient flow rate. That means the top of the source water pool (pond level, storage tank), is at least 6 feet or more above the livestock water tank location. For 50- to 100-head cow herds, a 2-inch PVC pipe with 6 feet of head should meet livestock needs.

Siphon systems have a limitation on how high the water can be lifted above the source water level and this is dictated by the barometric pressure (one atmosphere is approximately equal to 33 feet of sea water or 14.7 pounds per square inch). Siphon lifts over 30 feet are difficult to maintain. The water molecule pulls apart at siphons approaching 30 feet.

Gravity-flow systems are easy to start as they always have positive pressure. Valves regulating inline water flow are required.

While siphon systems may be difficult to start, after the siphon flow is established, the flow rate and pressures are similar to a gravity-flow system, except for the friction loss from the additional length of pipe necessary to establish the siphon.

A siphon is started by completely filling the tube/pipeline between the water source and the tank, ensuring all air is eliminated. This can be difficult. In smaller lines, up to 2 inches in diameter, the solution is to pump the pipeline full at a high speed from the bottom end, allowing the air and water to escape to the surface of the water source. This process works with larger diameter pipes if an adequate flow-rate pump is available. A flow rate fast enough to push the air and air bubbles out of the pipe is necessary for this method of air elimination.

When the pipe diameter/volume is too large to be easily pumped with the equipment at hand, an alternative method can be used to eliminate air. Install shutoff valves on both the intake and the discharge ends and a tee at the highest point in the siphon pipe. Close the end valves, open the tee valve, and fill the pipe with water. Close the tee valve, first open the intake valve, then the discharge valve and siphon should begin flowing.

Siphon issues have been addressed by using a battery-powered sump pump connected to the pipe intake and running it for a brief period each day to provide continuous air elimination. A timer turns the pump on and off. A solar panel recharging setup can supply power to the battery, or, for occasional need, a vehicle battery can be used instead with a cord to the pump.

Water-Powered Pumping Systems

Overview

Water-powered pumping systems, including sling or ram pumps, require no power other than moving water. An abundant source of water is required for water-powered systems. Water-powered pumping systems are usually considered low cost and have a long life, but they may not be able to deliver adequate flow to provide water to a livestock herd unless multiple units are installed.

Advantages

- Available in a range of sizes for small watering systems.
- Long life.
- No external energy source.
- Low maintenance.
- Well-suited to remote locations with an abundant water source.
- Long delivery lines and high lifts can be achieved under some conditions.

Limitations

- Requires adequate year-round surface water flow.
- Pumps will not work when the moving water freezes.

Design Considerations

Ram pumps have two check valves, which are the only moving parts of the system. Water flowing through the drive pipe from the stream into the pump picks up speed and drag, which trips the waste check valve closed. The sudden closing of the valve forces water into an air chamber, causing water pressure to build in the chamber as the air is compressed. Ram pumps can be shop-built or purchased commercially.

Water pressure forces open the discharge check valve, and a surge of water passes into the water delivery line before the valve snaps shut from the reduced pressure as the air chamber drains. The waste check valve reopens and the process repeats. The entire process of filling the chamber, pressurizing the water and discharging it can be accomplished in as little as a second. Successive surges of water raise the pressure in the delivery line.

The pump converts the low head, high flow of the water source (stream) to a high head, low flow of a pressurized water delivery. Most of the water flowing through the pump escapes through the waste check valve and flows back into the stream. Only a small proportion is pushed into the water line. The output flow rate depends on the amount of water flowing through the pump and the amount of fall to the pump compared to the lift heights of the delivery water.

The drive pipe is rigid and straight and the length should be about 150 times the pipe diameter. The drive pipe is generally constructed of galvanized steel to withstand the sudden water pressure increase when the waste valve snaps shut.

A standpipe can be installed on the inflow side of the pump to increase the water delivery flow rate by increasing how often the pump cycles, and the water pressure in the delivery line. Standpipes can compensate for a low head or long pipe length. After installing a standpipe, the pipe from the inlet to the standpipe is called the supply line and the pipe from the standpipe to the pump is called the drive line.

The standpipe should be about 1 foot taller than the elevation change between the intake location and the standpipe location. The diameter of the supply pipe above the standpipe is often larger than the standpipe diameter, which in turn has a larger diameter than the drive pipe. The delivery line is often smaller in diameter than the other pipes and is constructed of PVC. Avoid numerous fittings and bends and use a larger diameter pipe to minimize friction losses.

Select sites with at least 2 feet of elevation fall (head) between the water source (intake) and the ram pump. The higher the desired lift, the greater the fall necessary between the water source and the pump. Greater head and stream water flow will increase the delivery flow rate. Streams with steep gradients, waterfalls, or springs perched above streams can provide good sites for ram pump installations. Source water should be free of debris and sand.

Sling pumps contain many coils of pipe within a cone-shaped housing. A fan is connected to the body of the pump on the upstream side with a center swivel containing the delivery pipe so the pipe does not rotate. The fan is turned by the water flowing in the stream and causes the entire housing to rotate continuously. Water and air enter the coils of pipe as the housing turns. The turning of the housing forces the water counterclockwise through the pump and into the delivery line.

Where the stream is too shallow for the pump, a weir (small dam) can be installed to concentrate the flow and water depth. The pump must be anchored within the stream with stakes and cables, leaving it vulnerable to damage or loss during floods. The pump floats on the water surface, so it can take in both air and water as it turns.

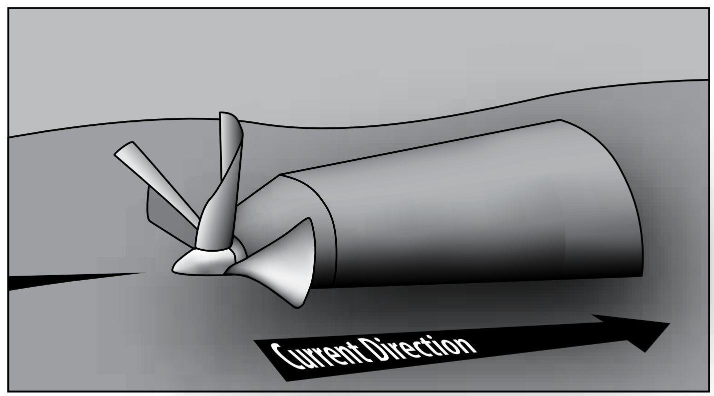
Winter operation of this pump is not practical in Kansas.

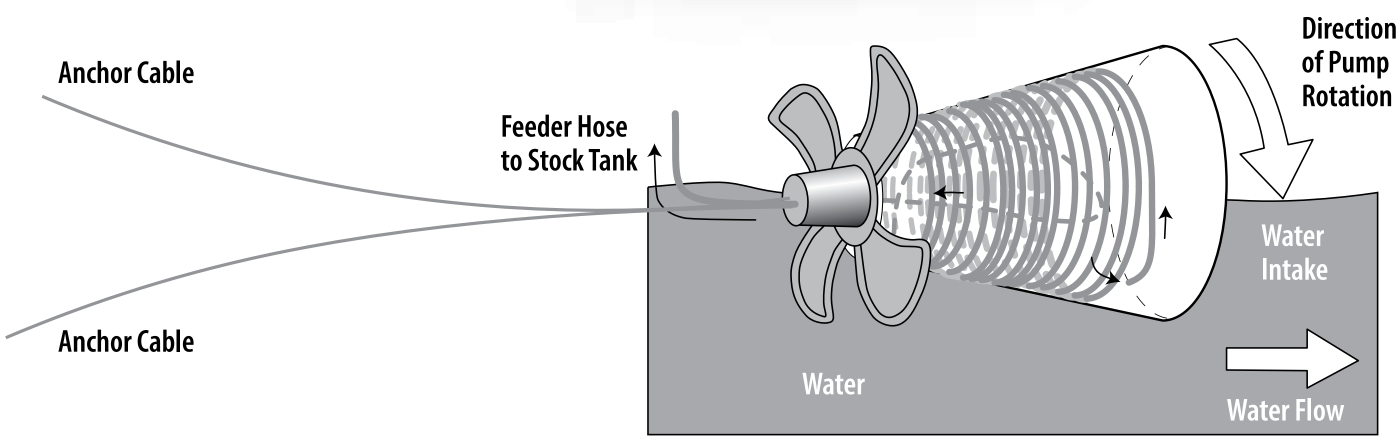
References

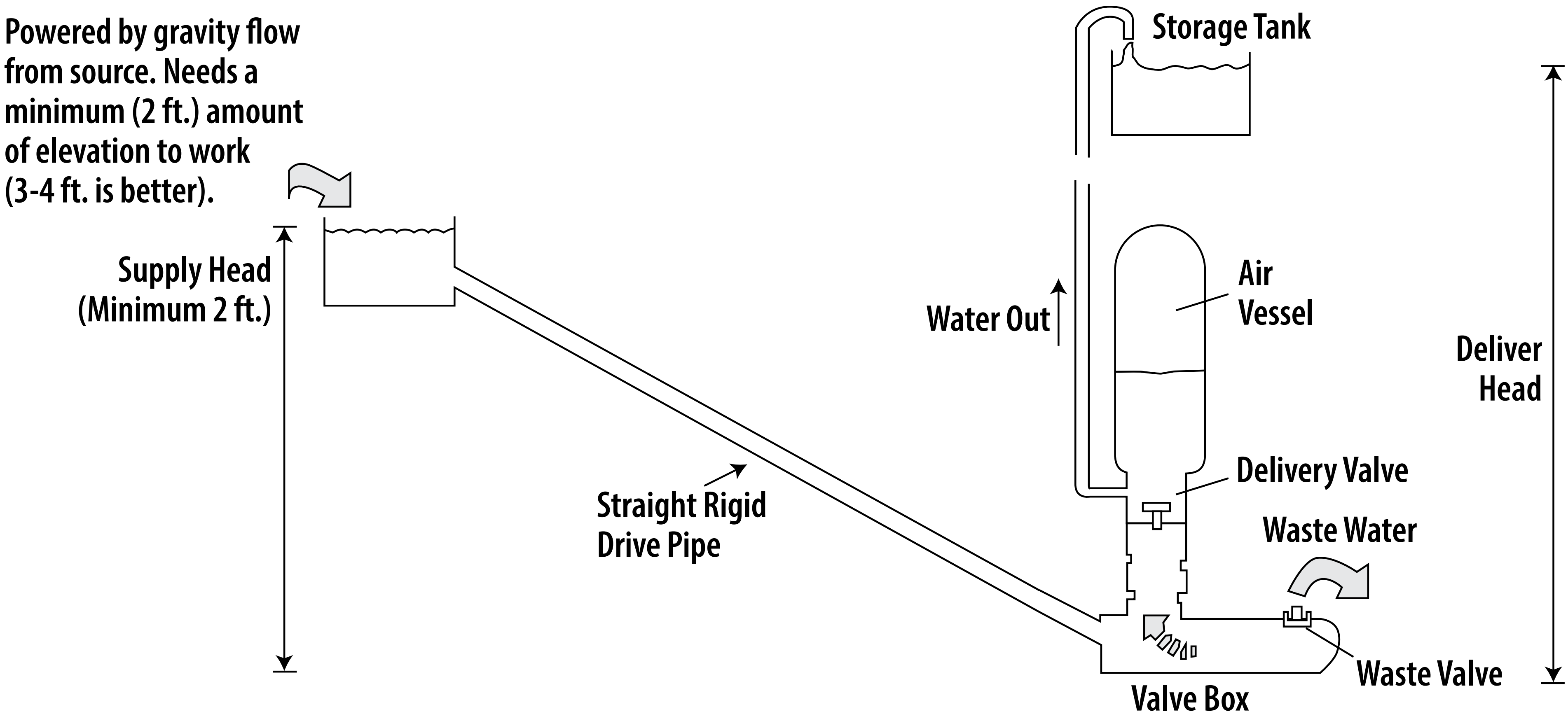
www1.agric.gov.ab.ca

www.susprep.com/off-grid-water/ram-pumps/

www.youtube.com/watch?v=J2c24Apl4fA






Powered by gravity flow from source. Needs a minimum (2 ft.) amount of elevation to work (3-4 ft. is better).
Supply Head (Minimum 2 ft.)
Straight Rigid Drive Pipe
Storage Tank
Water Out
Air Vessel
Deliver Head
Delivery Valve
Waste Water
Waste Valve
Valve Box

Animal-Powered Pump

Overview

Animal-activated pumping systems require livestock to learn to activate the pump; through their efforts, they can fill a drinking bowl or trough with water from a pond, stream, or shallow well. Pumps are generally activated by head action (nose pumps) or foot action. While simple and inexpensive, animal-activated pumps are best adapted for moving water short distances, about 20 feet vertically or 200 feet horizontally. One unit can supply water for a 25-cow herd. A draining bowl is needed in freezing conditions.

Advantages

- Simple, rugged, and portable.
- Livestock pump the water, no outside power source needed.
- Suitable for pond, stream, and shallow well water sources.
- Inexpensive.
- Livestock quickly learn how to activate the pump.

Limitations

- Small calves cannot operate the pump.
- Limited to moving water about 20 feet vertically or 200 feet horizontally.
- Special precautions needed for winter use.

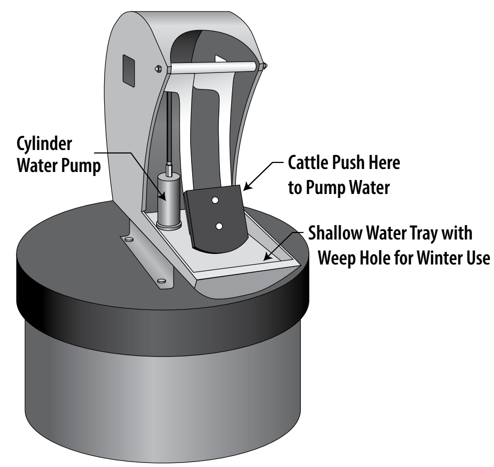
Design Considerations

Nose pumps consist of a diaphragm or cylinder (piston) pump with a paddle that is repeatedly pushed by the animal. Water enters the pump through a hose with a foot valve that is placed in the water source.

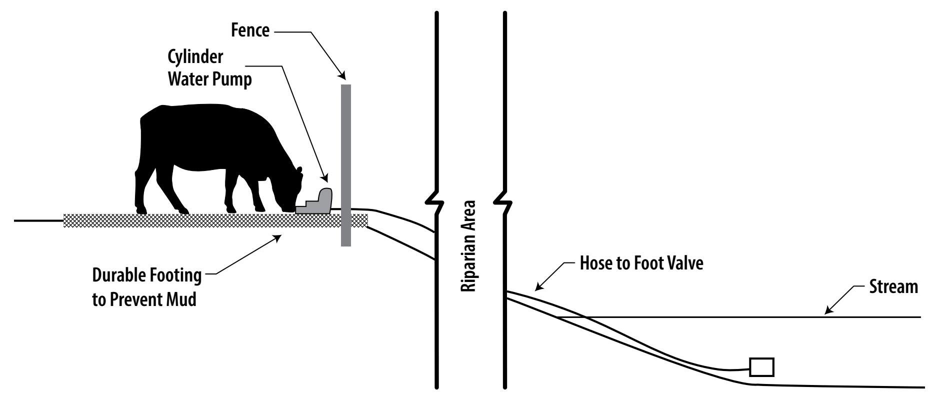
Each push delivers about one pint of water. The pump action is relatively slow and only one animal can drink water at a time, limiting the number of livestock that can be watered in a timely way.

Nose pumps are portable and must be pinned to a solid base to avoid shifting during use. Nose pumps can create about 20 feet of vertical lift or 200 feet of horizontal draw or an equivalent combination of lift and draw. The lower the head and the shorter the distance the water must be moved, the more easily the paddle is activated.

Foot pumps operate using the same principles but generally take longer for animals to learn how to use.



Nose Pump over a Wet Well




12.5
MCU control
SET voltage
Build-in timer
FULL protect
USB

Pumping System Components

Pumping water efficiently requires selecting and installing appropriate components. The pump should be selected based on the power supply available at the site and the required water flow. Pumping components are installed to control the flow rate and pressure under varying conditions.

An inexpensive centrifugal **pump** that runs continuously will avoid the frequent stop/start cycles that can cause greater pump wear and failure. With no pressure control components, a float (water-level control device) or shutoff valve at each drinking point controls the water level. A centrifugal pump continues to run even after the float or valve shuts off, so pressure is maintained for rapid water availability (Figure 1).

A **pressure switch** allows a pump to temporarily shut off while maintaining water pressure within a predetermined range, generally a range of about 20 pounds per square inch, and then restarts the pump when the water pressure drops below the range. Water pressure in the system fluctuates between pumping cycles but stays within the desired range. The pressure switch is generally installed on a separate tee in the water pipeline near the pump and power supply or near where the water enters the pressure tank, if a tank is used.

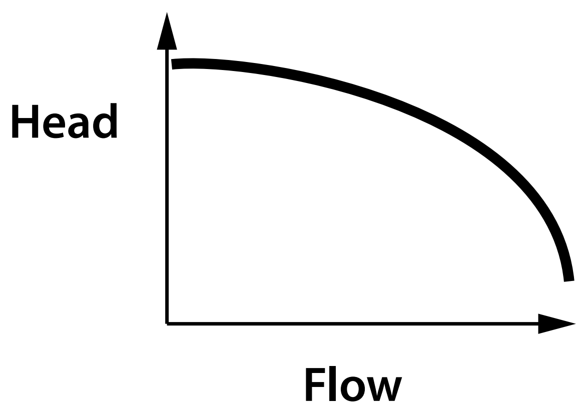


Figure 1. *Typical centrifugal pump performance curve.*

A **pressure tank** plumbed into the pressurized side of the water line reduces the number of times the pump cycles on and off while maintaining adequate water pressure. The pressure tank is a sealed vessel containing a volume of air, often in an air bladder that compresses and expands as pressurized water from the pump enters and leaves the container.

The pressure switch is set to the desired range. The air bladder is then filled with pressurized air when the tank is empty. The pressure should be 3 pounds per square inch lower than the lowest pressure of the water pressure switch range.

When the water pressure in the system reaches the high end of the range, the pressure switch turns off the pump (cut-out). When water drains from the system into a waterer, the air bladder expands as the water leaves the tank and water pressure decreases. When the water pressure drops to the low end of range, the pressure switch turns the pump back on (cut-in) to repressurize the system with additional water. The expansion and contraction of the air bladder keeps the water pressure within an acceptable range for a longer period of time while the pump is off compared to just using a pressure switch.

Leaks will lower water pressure more rapidly and result in more frequent pump cycling. The larger the tank, the greater the volume of water that can be pressurized.

A **pressure gauge** does not perform any water pressure control actions but is an important aid in evaluating water system performance. The pressure gauge displays the water pressure in the system and can verify that the pressure is being maintained within the desired range.

A **low water sensor** prevents damage to the pump when the well water level is below the pump intake level. When the water level is too low, the sensor shuts off the pump through wiring to the pump control box, which is designed to allow time for the well water level to recover before restarting the pump.

Check values and foot valves only allow water to flow in one direction through a pipeline. A foot valve is installed on the intake end of a watering system before the water enters the pump, while a check valve is installed on the pressurized side of the system. Foot valves are normally used to continuously maintain prime for the pump.

Water-level control valves (float valves) automatically maintain the water level in a livestock waterer or storage tank. Major types of these valves are diaphragm and mechanical (level-operated). The "Water-Level Control Valves" section of this handbook includes more details about these valves.

A **water pressure reducer** or **pressure reducing valve** lowers pipeline water pressure to a safe level and is most often used when the incoming water pressure is greater than 90 pounds per square inch, which is common in rural water district pipelines. A high water pressure is needed in the public water supply lines to maintain sufficient water delivery pressure for the most distant patrons. Many mechanical or lever action water-level control valves in livestock waterers fail to completely shut off when water pressures are extremely high. In some cases, the float may be nearly or completely submersed in the water and still not completely shut off water flow when the pressure is too high.

An **air relief valve** is placed in a pressurized water system at locations where air accumulates in the pipeline and water flow is reduced at the higher elevation points in the pipeline. Air relief valves are most often needed with longer and more complex pipeline systems. The air release valve is periodically opened to release trapped air. A livestock waterer placed at the highest elevation on a pipeline releases any trapped air without the need for a relief valve.

Shutoff valves are installed throughout a water pipeline system. Shutoff valves should be located on each branch of an extensive watering system so individual parts of the system can be isolated for maintenance and repair without shutting off water to the rest of the system, thus maintaining livestock water availability elsewhere in the pasture.

Shutoff valves are generally situated upstream of waterers and hydrants and preferably downstream of the pressure tank but before the pipeline branches out of the pump house, allowing pump components to be tested before releasing water to the entire system.

There are many styles of pipeline shutoff valves. The pipeline material often dictates the type of shutoff valve needed.

Stop-and-waste valves are used where a pipeline branch needs to be drained when not in use to prevent freezing. Often stop-and-waste valves are used for waterers or sections of the pipeline that are only used seasonally. Stop-and-waste valves have two openings: one that controls the flow of water (stop) and one that allows water to drain from that branch of the pipeline (waste).

Ball valves (or quarter turn valves) contain an internal ball with a hole through it. Turning the valve handle rotates the ball hole. Water goes through the valve when the hole lines up with the flow of water. When the hole is turned away from the flow of water, the flow rate is reduced and finally stopped.

Gate valves operate by sliding a retractable guillotine-type piece of metal (gate) across the flow of water to regulate water flow. The gate is attached to a threaded shaft extending from the middle of the valve and often ending in a circular handle.

Globe valves are constructed with a washer that fits into a seat inside the valve. The washer is attached to a threaded shaft with a circular handle at the end. Turning the handle moves the washer off or onto the seat. Water flow is regulated by the distance between the washer and the seat.

www.sciencedirect.com/topics/engineering/pressure-reducing-valve

Water-Level Control Valves

Water-level control valves automatically maintain the level of water in livestock waterers or storage tanks. There are two major types of valves: diaphragm and mechanical (lever operated) valves.

The flow rate is a major consideration when selecting a water-level control valve. The valve flow rate should match or exceed flow rate needed during the period of the highest livestock water demand, which is based on the type and number of animals along with the season of the year the tank will be used. Please review the "Daily Water Requirements for Livestock" section of this handbook for instructions on how to calculate the maximum water demand.

The incoming water pressure is another major factor when selecting the water-level control valve. Gravity-flow valves are designed for low pressures of 0 to 30 pounds per square inch. These valves are designed with larger orifices than higher pressure valves so the desired flow rate can be achieved. When the water pressure is higher than the design value, the valve may fail to completely turn off the water, causing tiny flow seeps not noticeable when the waterer is in use, but the seep can cut a groove in the orifice or rubber seat over time.

An additional consideration is the valve placement. Many livestock waterers or tanks are controlled with valves that are placed at or above the surface of the full tank, while other valves are designed to be placed under the water surface or at the bottom of the tank. Public water supply organizations often require all livestock water valves on their systems be "anti-siphoning," which means there must be air space between the water discharge point and the pool of water in the livestock tank. This keeps water in the livestock tank from contaminating the public water supply.

Water-level control valves come in two major types: diaphragm operated or lever operated.

Diaphragm-Operated Valves

Diaphragm-operated valves tend to have full-flow water flow to the selected water level, when the diaphragm then completely closes. These valves are usually enclosed in a plastic case. Diaphragm valves have a more complicated system including two tiny passages that sense and activate the diaphragm action. These tiny passages can be cleaned and then reinstalled by the producer, but the information that accompanies the valve may not discuss this maintenance or repair.

Diaphragm-operated valves tend to have an operating range of 5 to 150 pounds per square inch and may not be suited for gravity-flow systems.

Examples of diaphragm valves are:

- Jobe Mega flow (Photo 2)
- Jobe Topaz
- Jobe Vortex
- Apex Xtraflo
- Hudson — must be used vertically and cannot be used in a submerged placement (Photo 3).

Lever-Operated Valves

Franklin, Mirico, and similar valves found in many different brands of commercial waterers use a single plunger rubber seat (Photo 4). These can have orifices of three different sizes for different pressures and flow rates.

DURAPRIDE Pride of the Farm and Hawkey\Brower valves use one diaphragm seat and one "O" ring to create a seal (Photo 5).

Richie uses a plunger seat to seal and has three orifices for flow rates and pressure ranges up to 80 pounds per square inch.

Roberts and Watts valves are similar and are typical of brass valves used in agriculture. These often use threaded brass rods to attach the valve lever to the brass or plastic float. They come in a range of sizes which can be used to meet the desired flow requirements. A replaceable plunger rubber fits into a seat to shut off the valve.

Brass Valves

Watson valves are available in a wide range of sizes and flow rates (Photo 6). They are frequently used in tire tanks but are also ideal for gravity-flow and other waterer applications. The valve consists of an aluminum float attached by a chain to the lever.

Photo 3. *Hudson valve.*

Photo 2. *Jobe valve.*

Photo 4. *Franklin/Mirico-type valve.*


Photo 5. *Pride of the Farm valve.*


Photo 6. *Watson valve.*

PVC, HDPE, PEX, and Other Pipeline Materials

Piping materials for livestock waterlines include steel, galvanized steel, copper, polyvinyl chloride (PVC), high-density polyethylene (HDPE) roll pipe, and more recently, cross-linked polyethylene (PEX). Each pipeline material offers benefits and limitations.

Steel pipe is strong and readily available but requires threaded ends and frequently leaks at the joints. It is more difficult to install and repair, has a relatively higher initial cost and will eventually rust.

Copper pipe has a long life, but connections must be soldered, increasing installation time and effort. It is comparatively expensive.

PVC is strong, reasonably priced, easy to install, and sections of pipe and fittings can be quickly joined using solvents and glues. A wide variety of fittings and couplings are readily available for many applications.

HDPE hose has good UV (ultraviolet) resistance and is quite flexible, making it suitable for temporary watering applications when the pipeline is not buried. Rolls of HDPE allow the construction of long pipelines with fewer joints. Joints are made by using fuse welding with a heating unit, or by using barbed metal or plastic hose connectors. If the pipeline is to be buried, use clamps made of all-stainless steel to attach the barb fittings. An HDPE hose, full of water, will float because this material is lighter than water.

The highly flexible PEX material has excellent tolerance for freezing temperatures. It requires specialized installation tools and is often installed by a contractor. "Shark bite" fittings can be used by nonprofessionals where they are appropriate. Due to the cost of the fittings, PEX pipelines are relatively expensive, and they are generally only available in smaller diameter sizes.

Pipeline Network for Multiple Waterers

Overview

When several waterers are located relatively close to each other, a pipeline network may be less expensive than installing a separate pump, energy source, and direct pipeline to the water source for each waterer. Pipeline diameter is contingent on the combined length of the pipelines, differences in elevation, and combined water demand of all the waterers. A pipeline network design is specific to the site, the herd water requirements, and pasture arrangement.

Advantages

- A single water source, pump, energy supply, and storage tank can supply multiple waterers.
- May be less expensive and more reliable than developing a separate watering system for each waterer.
- Multiple water sources can be combined to deliver water to many waterers.
- Suited when power supply is limited to a single location, but water delivery is needed for multiple waterers.

Limitations

- Backup pumps and power sources are more important because a single failure impacts multiple waterers.
- Water source must have an adequate flow rate to supply all the waterers.
- Shallow rock layers can impede laying pipeline.
- Design must be specific to the site.
- May require a contractor to design and install.

Design Considerations

The assistance of a qualified engineer is usually required to determine pipeline sizes and valve locations to ensure adequate system capacity. The system may include air relief valves, vacuum relief valves, shutoff valves, water storage, and thrust blocking as well as pipeline and fittings.

Air relief valves release air that accumulates at high elevation points in the system so it does not restrict water flow.

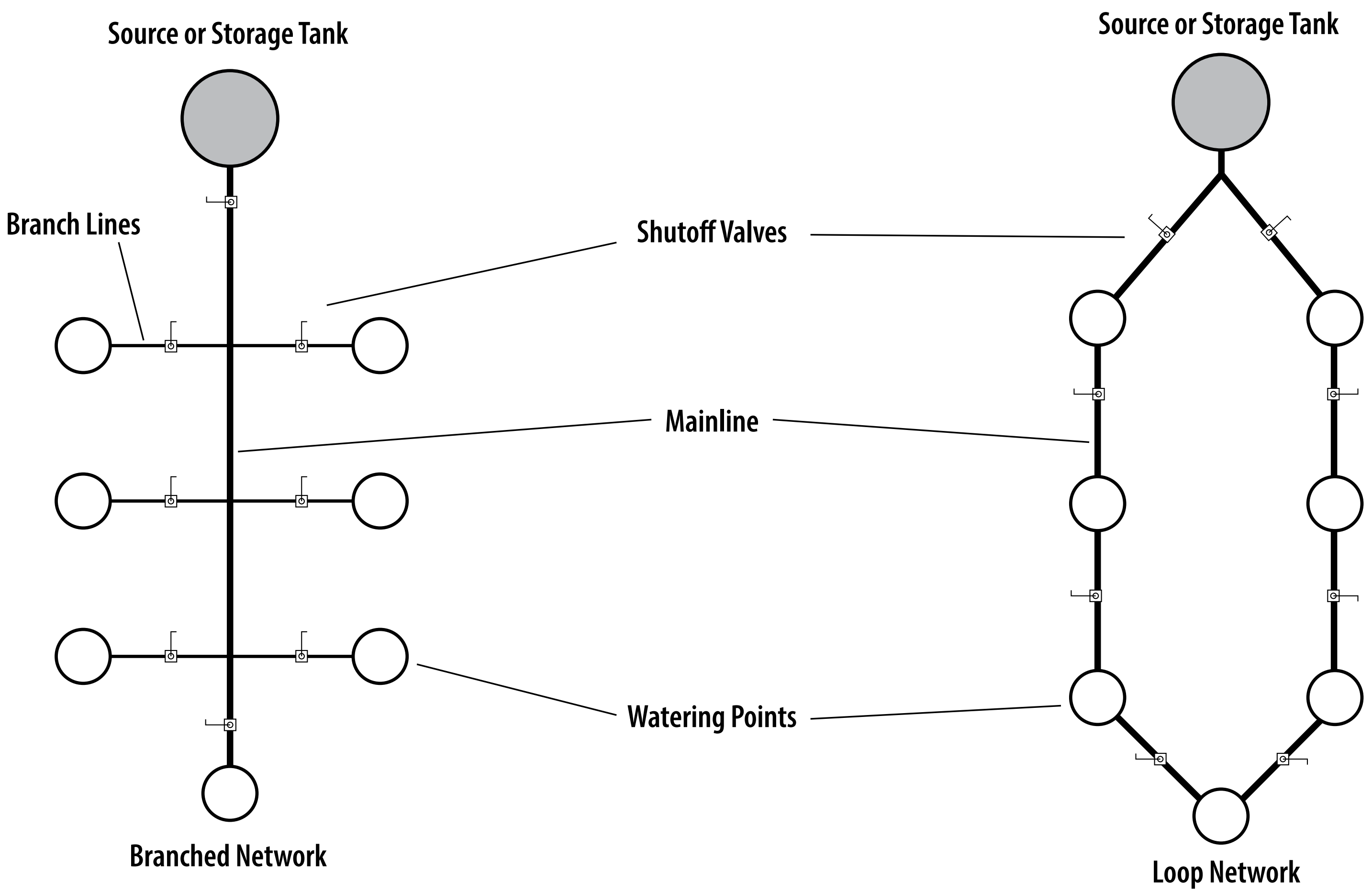
Vacuum relief valves prevent a vacuum from developing in the waterline on sites with large differences in elevation. A vacuum in the line can cause the pipeline to collapse or break. The vacuum relief valve is often combined with the air relief valve to minimize the number of fittings and reduce cost.

Shutoff valves are installed to allow sections of the pipeline to be isolated for maintenance and repairs. A pipeline network laid out in a loop configuration allows most of the network to remain functional while one section is being repaired. Valves should be installed for each waterer to allow repair and maintenance while the remainder of the waterers remain functional.

Elevated storage tanks use gravity flow to move water rapidly though the network to refill multiple waterers. Large diameter tanks with sufficient head of water within the tank also can provide gravity flow to additional waterers.

Pipeline specifications are tailored to the needs of each section of the network. Pressure losses resulting from pipeline length and pipe diameter, operating pressure, pressure surges, and the strength of the pipe must be considered. Pipe with walls heavier than specified can provide increased durability, years of service, and reduced repair costs. Fittings at least as strong as the pipe should be used. Do not use schedule 40 fittings on schedule 80 pipelines.

Water Distribution Arrangements



Loop networks with strategically located shutoff valves allow a section of line to be isolated for maintenance or repairs and still supply other watering points.

Water Storage Tanks

Overview

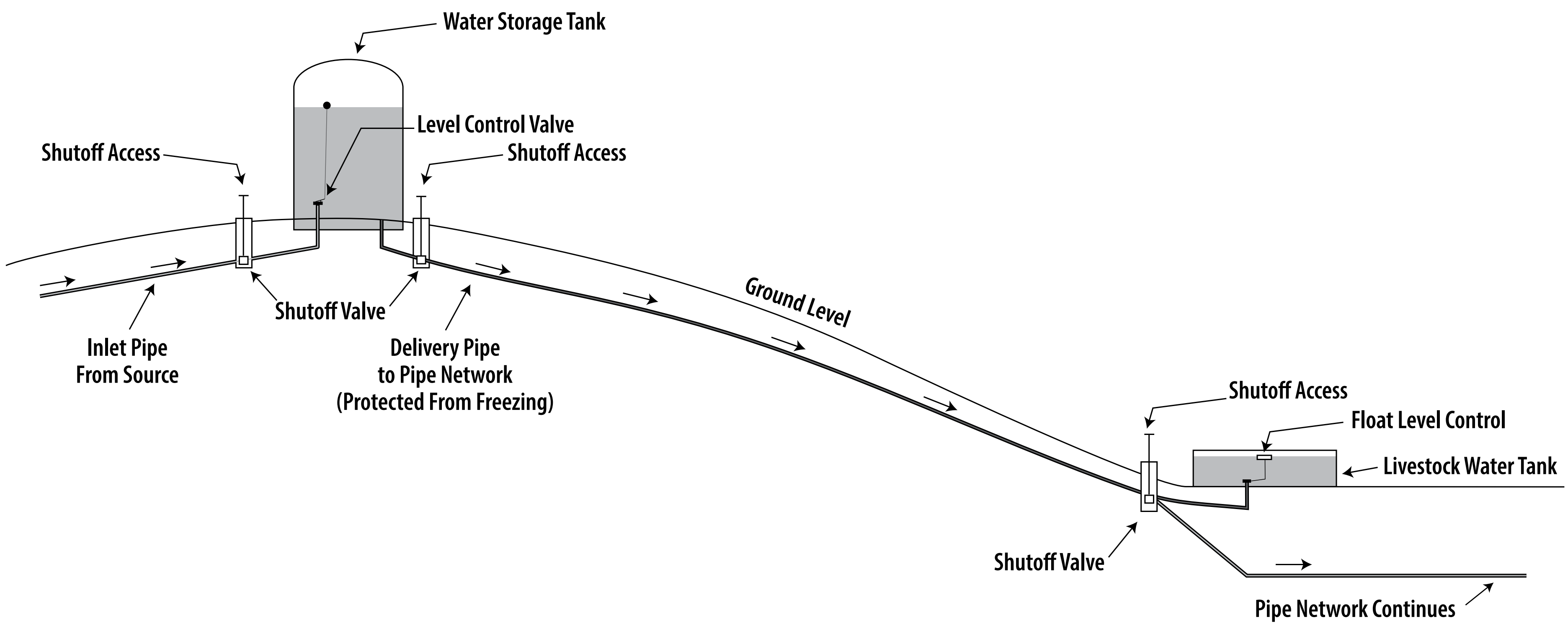
Water storage tanks provide a reservoir for when water is not immediately available from the source, such as still days in wind-powered watering systems, pump failures, or power outages. Storage tanks allow water from a steadily producing but low-volume source to accumulate in sufficient quantities to meet the needs of a herd with heavy water usage during a brief time.

Advantages

- Multiple waterers can be supplied from a single storage tank.
- Provides rapid refill rates during peak water demand periods.
- Provides a backup water source for intermittent power outages in all types of pumping systems.
- Well suited to a low flow system that is adequate for daily demands but inadequate during periods of peak demand.
- Allows temporary grazing of cover crops or crop residues away from a water source by using hauled water.
- Can be used on rented property and removed at the end of the rental period.
- Very reliable and requires little maintenance.

Limitations

- Terrain may be unsuitable for gravity flow from storage tank to waterers.
- Floats that malfunction can cause the tank to quickly drain.
- May require continuous use during the winter to prevent freezing.



- Must be continuously weighed down with water or anchored down to prevent wind movement.
- Tanks to hold a sufficient quantity of water for livestock use may be difficult to find.

Design Considerations

A water storage tank size is primarily determined by the amount of water needed (gallons per day) and the water supply recharge available, including the flow rate from the water source or the frequency and volume of water delivery of hauled water. Pipeline friction losses should be considered when using a tank on an elevated site for gravity flow to waterers. All pipeline connectors, including water control valves and connections to water storage tanks and waterers, should maintain at least the same inside diameter as the incoming supply pipeline to avoid a restriction of the water flow. Consider obtaining expert assistance when selecting a storage tank.

Tanks are constructed of steel, galvanized steel, fiberglass, concrete, or plastic. Agricultural nurse tanks work well and range in size from 500 to 1,600 gallons. Recycled oil field and fuel tanks can be cleaned and adapted for use as water storage tanks. Steel tanks can be quite large but may have a short life, which can be extended by the use of coatings. Recycled stainless steel milk tanks are durable but more expensive.

Storage tanks should be fitted with a float valve that shuts off when the tank is full. A drain should be installed on the downhill side if there are elevation differences. Shutoff valves should be installed on the water entry and exit pipes so the tank can be isolated from the watering system for repair and maintenance.

Considerations for Sizing a Watering System

Water is essential to animal growth. Correctly sizing the watering system ensures the water needs of livestock are met.

Definitions

The water requirement is how much water is needed per day to meet an animal's nutritional requirement. The daily water requirement is typically measured in terms of gallons per day based on number of animals and animal body weight.

An **animal unit** (AU) is 1,000 pounds of body weight and is used to calculate stocking rates and water needs. An individual animal's AU equivalent can be calculated by dividing the weight of the animal by 1,000.

Animal units can be calculated for an entire herd using the following formula:

Total herd animal units = (average weight of an animal in the herd) × (number of animals) ÷ 1,000

Water demand (peak water usage) is based on the maximum amount of water consumed during a 15- or 30-minute interval during the day when each animal in the herd requires an opportunity to drink. Water demand is an estimate of the maximum amount of water needed to rapidly refill a stock tank, trough, or water bowl and is generally measured in gallons per minute (volume per time period). Refill rate becomes increasingly important as herd size increases.

Flow rate is the volume of water that crosses a point in the pipeline during a time period and is measured in gallons per minute (gpm).

Total pressure drop (or head loss) is a sum of the reductions in pressure from the difference in elevation between the water source and the pipe outlet at the delivery point, plus the friction loss due to the velocity of the water moving through the length of pipe, plus the loss of pressure by each coupler, ell, and valve used along the pipeline. Pressure drop is measured in feet of head or pounds per square inch (psi).

Refill rate is the time required for the water in a tank or waterer to be replenished after animals have been drinking. It is measured in gallons per minute.

Drinking space is the linear space of tank access required for one animal to drink from a tank. About 20 inches of space should be allowed for each animal drinking from a circular tank and 30 inches for rectangular tanks. Table 2 offers estimates of the number of water drinking spaces provided by tanks of differing dimensions.

Seven Steps For Sizing a Watering System

Seven steps for sizing a watering system are discussed in the following text. Obtaining expert advice and review is recommended for best results.

Step 1: Determine daily drinking water requirements.

The daily drinking water requirement is a function of the number of animals and body weight. Generally, a minimum of 10 gallons per animal unit of water is required daily during mild and cold weather. During hot weather, water consumption can double to 20 gallons per day per animal unit. Table 4 compares the water requirements based on number of animals and time of year assuming one animal is equal to 1 animal unit. Often, the average body weight is different than 1,000 pounds, and water needs should be adjusted accordingly. The guidelines in Table 1 assume the watering system will supply all water needs of the livestock and does not consider water intake from other sources such as wet forages (silage, distiller grains, or cover crops), forages covered with dew, snow, or rain, or ephemeral water ponds in low spots in pastures.

The water system should be sized to meet 100% of the current daily water demands based on 100% full stocking of the grazing area.

Step 2: Determine water demand (peak water usage).

When water tank capacity or space around a waterer is limited, waterers must refill rapidly to allow the entire herd to drink in a relatively short amount of time. Limited space is defined as when 10% or fewer of the animals in the herd are able to drink from the waterer simultaneously.

Table 4. *Daily water requirements (gallons/day/animal unit) based on number of animals vs. cold or hot weather.*

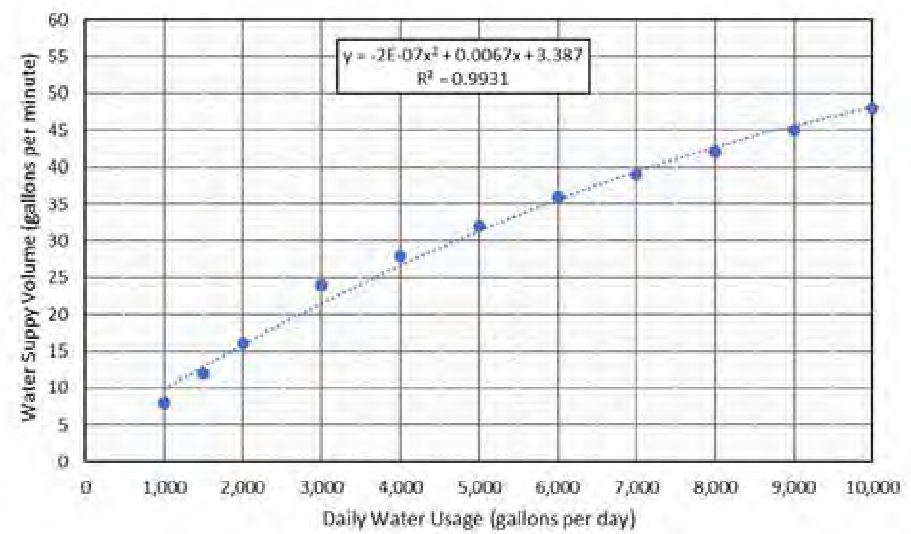
Number of Animals*	Daily Cold Weather Water Requirements	Daily Hot Weather Water Requirements
1	10	20
25	250	500
50	500	1,000
75	750	1,500
100	1,000	2,000
125	1,250	2,500
150	1,500	3,000
175	1,750	3,500
200	2,000	4,000
225	2,250	4,500
250	2,500	5,000
275	2,750	5,500
300	3,000	6,000

*One animal unit is assumed to weigh 1,000 lbs

Animals experiencing a lengthy wait for the tank to refill spend less time grazing, and animal performance will be negatively affected. A dominant animal may limit the access of other cattle to the water tank if the watering point is too small or only has a single watering point.

Guidelines for water demand based on daily water usage can be found in Figure 2. For example, if the daily water usage is 2,000 gallons per day, the pumping system should be able to pump approximately 15 gallons per minute. The daily water supply could be met if the pump operated about 2¼ hours per day. As water requirements increase, such as during hot weather or with growing animals increasing in weight, the amount of time the pump will need to run to replenish the watering tank increases.

Figure 2. *Adaption from Brown (2006)[1] of recommended peak water demand (gallons per minute) based on daily water usage (gallons per day).*



If a watering system has a continuous water flow of less than 5 gallons per minute, the water trough must have enough storage capacity to allow multiple animals to drink simultaneously and concurrently.

Generally, water demand should be considered adequate if a system pumps 10 gallons per minute or more, with no more than 50 animals in the pasture.

Storage capacity can be achieved by increasing the size of the tank (in-tank storage) or by adding a storage reservoir between the water source and the tank. If the decision has been made to install a storage tank or other additional storage capacity, there are three basic options.[2]

- Option 1 – install a water storage tank regardless of continuous flow rate.
- Option 2 – if continuous flow rate is less than 5 gallons per minute, water storage tanks should be installed to allow multiple animals to simultaneously drink during periods of peak demand.

Table 5. *Number of water drinking spaces required for water tanks based on tank diameter (ft) and water troughs with straight sides based on trough length (ft).*

Water Tank (Round)			**Water Trough (Straight Sides)**		
Tank Diameter (feet)	Water Drinking Spaces*	Recommend-ed Animals Per Tank**	Trough Length (feet)	Water Drinking Spaces/Side*	Recommend-ed Animals per Trough Side**
4	8	80	6	2	20
6	12	120	8	3	30
8	16	160	12	4	40
10	19	190	16	6	60
12	23	230	20	8	80
16	31	310	24	9	90
*Assumes 20 inches of drinking space per animal **Assumes water space available for 10% of animals			*Assumes 30 inches of drinking space per animal **Assumes water space available for 10% of animals		

- If the continuous flow rate is 5 gallons per minute or higher and there is no storage tank, the required continuous flow (refill rate) should equal 1 to 2 gallons per minute per drinking space.

Water tanks that can hold an entire day's requirement of water for the herd need a minimum flow rate equal to the daily water requirement ÷ 1,440 minutes per day.[2] When the flow rate exceeds water requirements and there is no shutoff valve, an overflow pipe should be installed to prevent water from spilling over the tank edge and accumulating around the base of waterer.

Step 3. Determine the number of drinking spaces needed.

At least 10% of the animals in a pasture or pen should be able to drink simultaneously.[2] About 20 inches of space should be allowed for each animal drinking from a circular tank and 30 inches for rectangular tanks.[2] Generally a minimum of two water points is necessary to prevent the dominant animal in the herd from standing at or in the water point during periods of heat stress or hot weather and restricting access by other animals.

Water tanks can be installed along a fence or structure that restricts access to only one side of the tank and will provide only half the number of drinking spaces. When cattle are drinking from both sides of a tank, the tank width should be a minimum of 30 inches.

See Table 5 for estimates of the number of water spaces provided by tanks of differing dimensions.

Follow the manufacturer's drinking space recommendations for cup, bowl, or small tub waterers. If recommendations are not available, provide one drinking space per 20 animals.[2] This assumes water is available in each bowl, and livestock drink one at a time.

Water intake by beef cattle occurs during an 8- to 10-minute period each day. If water is readily available, cattle will visit the watering point six to 10 times per day. Cattle consume water at an average rate of 6 gallons per minute, but consumption rate can vary between 2 to 12 gallons per minute. While cattle may be able to consume their daily water supply in a relatively short time during each visit, they also need time to move to and from an open water space as it becomes available.

Cattle may consume their entire daily water intake in one visit to a water source if they must travel a long distance to water, resulting in increased drinking time per animal and requiring enough drinking spaces for 15% to 20% of the herd to drink simultaneously. Consider providing additional drinking spaces and faster refill rates when pastures are large, distances to water are long, waterer storage capacity is low, or herd size is large.

Step 4. Determine storage volume requirements.

If a storage reservoir cannot be refilled in one hour, then a storage reservoir should be sized large enough to store all the water that will be needed by the herd for one day. Wind or solar powered watering systems need a storage reservoir that holds enough water for two to three days (stock tank volume + storage tank volume).

Table 6 shows the volume of water available in a round storage tank based on diameter and water depth. The diameter will determine how many drinking spaces are available. The tank depth and diameter determine how much water the tank will store. For example, if a tank is 12 feet in diameter and water depth is 12 inches, then the tank will hold 846 gallons. The reservoir capacity is based on the depth of water the cattle can easily reach rather than the full depth of water held in the tank: Even if the tank is 20 inches high, cattle may only be able to reach the top 15 inches of water.

Step 5. Determine available water output.

Table 7 provides estimates of the water output for several types of watering systems. Seepages and springs may have continuous flow but at a slow rate of discharge. If livestock are consuming 6 gallons per animal per drinking event and the flow rate is 1 gallon per minute, it will take 6 minutes of refill time before the next animal can drink unless there is water storage available either in the tank or from a storage reservoir.

Step 6. Determine pipe diameter.

Pipe size requirements are determined by the water demand or peak water flow rate and head pressure available. Peak demand for a seepage or spring system generally equals the continuous flow rate. Flow rates for several pipe diameters are shown in Table 8 when water velocity is 4.5 feet per second or less.

When water velocity is greater than 4.5 feet per second, pipe friction loss must be considered when calculating the required head pressure. Pipe friction can be decreased by selecting a larger diameter pipe.

It is better to oversize rather than undersize the watering system to avoid limiting potential herd growth due to a lack of adequate water delivery. By using a slightly larger pipe size than the design size, the watering system can accommodate future herd growth by having the capacity to supply additional water troughs or tanks.

The most common pipe type in livestock watering systems is PVC pipe. Tables 8 and 9 are based on PVC pipe and must be adjusted if using other piping material. The pressure drop due to water velocity is generally assumed to be negligible if the water velocity is less than 5 feet per second (fps) through the pipe. The water velocity in Tables 8 and 9 is assumed to be 4 feet per

Table 6. *The storage volume (gallons) of different size round tanks (feet) vs storage depth of water (inches) available for drinking.*

Tank Diameter (feet)	Depth of Water in Round Storage Tank (inches) Available for Drinking				
	9 inches	12 inches	15 inches	18 inches	24 inches
4	70 gallons	94 gallons	117 gallons	141 gallons	188 gallons
6	159	211	264	317	423
8	282	376	470	564	752
10	441	587	734	881	1,175
12	634	846	1,057	1,269	1,692
16	1,128	1,504	1,880	2,256	3,008

Table 7. *Difference in daily water available for typical watering systems and number of animal units that may be watered during cold/mild and hot weather.*

Type of Water Supply System	Load Size (gallons/load) or Pump Volume (gpm)	Loads or Pumping Time/Day	Available Water per Day (gallons)	Cold Weather Water Consumption 10 (gal/AU/dy)	Mild Weather Water Consumption 20(gal/AU/dy)
				Maximum Animal Units* Based on Water Available**	
Haul	300 loads	2 loads/day	600	60	30
Seepage	0.5 pump	24 hours/day	720	72	36
Spring	1 pump	24 hours/day	1,440	144	72
Wind/Solar	2 pump	6 hours/day	720	72	36
Wind/Solar	4 pump	6 hours/dy	1,440	144	72
Gravity Flow	5 pump	12 hours/dy	3,600	360	180
Well or Rural Water	10 pump	8 hours/dy	4,800	480	240
Well or Rural Water	15 pump	8 hours/dy	7200	720	360

*An animal unit is assumed to equal 1,000 lbs of live weight
** Assumes 100% of water consumption is supplied by watering system

second to minimize the affect of water velocity. The total pressure drops in Tables 8 and 9 are the difference between the difference in elevation between the pipe inlet at the water source and the pipe outlet at the delivery point. The total pressure drops increase as the pipeline length and inside roughness of the pipe increase (head loss).

Step 7. Impact on head pressure.

When water is moved through the pipeline, from the water source to the waterer, the distance the water can be moved is determined by the pipe material, diameter of the pipe, the volume (gpm) and head pressure (psi). Friction loss of the pipe is determined by the velocity of the water in the pipe, (feet per second), and roughness coefficient of the pipe. Each elbow, valve, coupler or any other joints or insertions along the pipeline create turbulence and add to friction loss. Friction loss is measured as pressure drop for each 100 feet of pipeline plus the loss for each additional pipe fitting.

Table 9 shows the distance water can be transferred as a function of nominal pipe diameter (inches), head pressure (psi), and water flow rate (gpm) for PVC pipe. Other pipe materials such as steel or copper will have different transfer distances.

Summary

These seven steps provide basic guidelines for sizing a watering system. Local experts can provide additional insight to ensure livestock water needs are met.

Example of a Water System Design

A pasture can support 30 cattle weighing 750 pounds during the summer months. The watering system is a solar pump system pumping 5 gallons per minute. The distance from the water source to the round water tank is 200 feet and vertical head pressure is 10 feet.

Determine the tank diameter and recommended pipe diameter.

Table 8. *Recommended minimum pipe diameter based on water flow rate (gpm).*

Pipe Diameter (inches)	Water Flow Rate (gallons/minute)*					
	5	10	15	20	25	30
1	OK	—	—	—	—	—
1.5	OK	OK	OK	—	—	—
2	OK	OK	OK	OK	OK	—
2.5	OK	OK	OK	OK	OK	OK
3	OK	OK	OK	OK	OK	OK

* OK indicates pipe diameter is OK to use with given water flow rate (gpm) since the water flow rate is less than 4.5 fps
— indicates pipe diameter is not recommended at given water flow rate

Design Considerations

Step 1: Convert to animal units (A.U.).

30 head × 750 pounds/head/1,000 pounds = 22.5 animal units

Step 2: Determine daily water requirements for summer months.

22.5 A.U. × 20 gallons per day per A.U. = 450 gallons per day

Step 3: Determine minimum number of water spaces.

30 head × 10 % minimum water spaces = 3 head

Or

30 head × 20% minimum water spaces = 6 head (if the cattle are in a large enough pasture that they only drink water one time per day)

Step 4: Determine round tank diameter.

Using Table 5, one 4-foot diameter tank will provide drinking space for 8 head. Using Table 3, a 4-foot diameter tank has a water volume of 141 gallons in 18 inches of depth. A 6-foot-diameter tank has the capacity for 211 gallons in 12 inches of water depth.

The three-day storage recommendation for solar powered water systems would require 1,350-gallon total (450 gallons per day × 3 days). The options are ***one 16-foot-diameter stock tank*** or ***one 4-foot stock tank*** with a 1,250-gallon storage tank gravity flowing to the stock tank.

Step 5: Determine the water demand (gallons per minute).

Using Figure 2 and based on daily water requirements of 450 gallons per day, the minimum water demand is approximately 5 gallons per minute. If the eight head were to drink 2 gallons per head per minute, the demand rate would be 16 gallons per minute.

Step 6: Determine pipe diameter.

Two options for stock tank sizes were determined in Step 4, the 16-foot stock tank that can hold the three-day recommended storage of 1,350 gallons or a 4-foot stock tank that will hold 141 gallons with a 1,250-gallon storage tank above it that will gravity flow water into the stock tank.

Option 1, using the 16-foot stock tank:

Use Table 8 to find that a 1-inch pipeline can carry the 5 gallons per minute flow from the pump. Table 6 confirms that the 1-inch pipeline with 20 to 30 psi can move water further than the proposed 200 feet. Therefore, select a 1-inch PVC pipe to convey the water from the pump to the stock tank.

Option 2, using the 4-foot diameter stock tank with the 1,250-gallon storage:

Use Table 8 to find that a 1-inch pipeline can carry the 5 gallons per minute flow from the pump. Table 6 confirms that the 1-inch pipeline with 20 to 30 psi can move water further than the proposed 200 feet. Therefore, select a 1-inch PVC pipe to convey the water from the pump to the storage tank.

The flow rate for filling the stock tank must be 16 gallons per minute so the livestock can drink in a timely manner. In Table 9, in the Gravity-Flow Systems section, looking at the 20-gallons-per-minute column, when the tank is full (10 foot head), a 1-inch line would work to deliver the water 10 feet or less. But when the tank is less than half full, as may occur during cloudy weather since this is a solar-powered system, the water in the lower half of the tank will have less than 5 foot of head pressure, so a larger pipe diameter is required. While technically a 1½-inch pipe could serve as the gravity-flow delivery pipe, assuming the distance is short, a more dependable solution would be to use a 1-inch pipe to carry the water from the pump to the storage tank and a 2-inch pipe to serve as the gravity-flow water source to the smaller stock tank.

References

1 Brown, L. 2006. Livestock water system design #1. Selecting flow rate, pressure, trough size and storage. Ed. BC Livestock Watering Handbook, 1990: 2-4, BC Ministry of Agriculture and Fisheries. B.C. Livestock Watering Handbook - Province of British Columbia (gov.bc.ca)

2 Marsh, L. 2001. Pumping water from remote locations for livestock watering. Publication 442-755. Virginia Cooperative Extension. Virginia Tech. Blacksburg, VA.

Table 9. *Distance water can be transferred based on water flow rate (gallons per minute) and head pressure drop (feet of head or psi).*

System	Pipe Diameter (inches)	Flow Rate (gpm) 5	10	15	20	25	30
Gravity-Flow Systems 2.2 PSI (or 5 ft. head)	1	120	40	20	10	10	10
	1.5	950	270	130	80	50	40
	2	3,240	900	430	250	170	120
	2.5		2,130	1,010	600	400	280
	3			2,920	1,720	1,140	810
Low-Pressure Systems 20 PSI eg. 20-40 Pressure Switch (or 70 ft. head)	**Pipe Diameter (inches)**	**Flow Rate (gpm)** 5	10	15	20	25	30
	1	1,590	450	210	130	90	60
	1.5		3,670	1,740	1,020	680	490
	2				3,490	2,310	1,650
	2.5						3,910
	3						
Medium-Pressure Systems 40 PSI eg., 40-60 Pressure Switch (or 100 ft. head)	**Pipe Diameter (inches)**	**Flow Rate (gpm)** 5	10	15	20	25	30
	1	2,050	570	270	160	110	80
	1.5		4,720	2,230	1,310	870	620
	2				4,480	2,970	2,120
	2.5						
	3						
High-Pressure Systems 60 PSI eg., 60-80 Pressure Switch (or 140 ft. head)	**Pipe Diameter (inches)**	**Flow Rate (gpm)** 5	10	15	20	25	30
	1	1,370	380	180	110	70	50
	1.5		3,150	1,490	880	580	420
	2			5,090	2,990	1,980	1,410
	2.5					4,700	3,350
	3						
Very-High-Pressure Systems 80 PSI or Greater (or 185 ft. head)	**Pipe Diameter (inches)**	**Flow Rate (gpm)** 5	10	15	20	25	30
	1	4,200	1,170	550	330	220	160
	1.5			4,580	2,690	1,780	1,270
	2						4,350
	2.5						
	3						

Estimating Water Flow Rate Needs

Animals behave differently depending on the number of animals and the distance to feed, water, and resting areas. If the distance to water and feed is less than 1,000 feet, most animals act as individuals and obtain feed and water as individuals or in small groups.

If the feed and water distance (high hills and deep valleys may reduce this value) is greater than 1,000 feet, animals start forming a herd mentality, meaning that they roam as a group and tend to come to water as a single group

When animals desire water, their drinking place and time should be available so that each animal can consume their desired amount. Best results are achieved when animals are within 1,000 feet of the waterer.

To supply water to waterers designed for a small number of animals at one time, design the water flow to deliver 2 gallons per minute per head that drinks at one time. For example, if there is room for two cows to drink from the waterer, the minimum flow rate to the waterer should be 4 gallon per minute. Commercial waters usually specify a required flow rate for a recommended number of animals.

If the pasture distance to waterer is greater than 1,000 feet or all the animals come to water as a herd group, the waterer (usually a drinking tank) should be designed to accommodate 10% to 20% of the herd at a time and be able to supply half of the daily water requirement of the herd. Each animal around the water tank should average about 10 minutes to position and consume water, and then move away. Each drinking animal (500-pound cattle) should have 20 inches of space at a circular tank and 30 inches at a straight tank. In herd situations, calves may get pushed back until the cows have finished drinking.

Natural Resources Conservation Service (NRCS) Practice Standards specify a water system capacity of at least 30 gallons per day (at 90 degrees Fahrenheit) per 1,000 pounds of livestock weight. Pipelines (and pumps) should be sized to supply the peak demand of the herd in 12 hours or less.

Daily Water Requirements for Livestock

Daily water consumption of grazing livestock depends on the physical condition and size of the animal and the environmental conditions that surround the animal.

Factors that affect livestock water consumption are:

- Weather conditions, temperature, sunshine, shade, wind.
- Livestock travel distance to water.
- Water quality.
- Water temperature.
- Trough space and herd crowding at waterer.
- Type, moisture content and amount of feed consumed.
- Light level, time of day.
- Animal activity level.
- Physical dimensions of water access and depth of water.

Water is an essential nutrient for livestock, and animals with a limited water supply can have health challenges. Producers need to have both a summer and a winter plan to provide adequate water to cattle. A cow typically drinks 1.5 gallons of water per 100 pounds of weight each day in summer and 0.75 gallons in winter. Water is the most important nutrient in a winter event such as a snow and ice storm.

Producers who depend on electricity to fill cattle waterers and to keep them from freezing should have a backup generator for use during power outages. If livestock stop drinking water, check for stray voltage.

Water Consumption of Livestock

A good rule of thumb is that a horse needs at least a gallon of water per 100 pounds of body weight. For the average horse, this equals 10 gallons a day. Water requirements vary greatly according to the weather and the level of work that the horse is doing (Table 10). For instance, if the horse is exercising in hot, humid weather, it may need 2 to 4 times the minimum amount.

Water consumption increases with increased temperature, salt intake, and protein intake.

Table 10. *Livestock daily water requirements.*

	Average Gallons per Day	Pounds Water per Pounds Dry Feed	Air Temperature		
			40°F	60°F	80°F
Cows					
dry and bred	6-15				
wintering pregnant			6.0	7.4	
nursing	11-18		11.4	14.5	17.9
dairy	15-30				30-40
Feeders	4-15				
calf	4-5				9-10
small calves		0.6-0.84			
large calves		0.42-0.66			
growing cattle @600 lb.			3-8		8-13
growing cattle @800 lb.			6.3	7.4	10.6
finishing cattle @800 lb.			7.3	9.1	12.3
feedlot cattle @1,000 lb.			8-13		14-21
beef	8-12				20-25
Bulls	7-19		8.7	10.8	14.5
Sheep and Goats	2-3				3-4
Llamas	5				
Horses	10-15				20-25
Swine	6-8				8-12

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National Research Council. 1996. Nutrient requirements for beef cattle, 7th edition.

Livestock Waterers

Livestock Waterer Comparison Chart

Tank Type	Primary Advantages	Primary Limitations	Initial Cost	Maintenance Cost
Concrete	• Long useful life • Low operational costs	• Heavy • Not always readily available at farm supply stores	$-$$	$
Tire	• Simple • Inexpensive • Durable • Long useful life	• Effort required to remove sidewall • Limited tire sizes • Limited tire sources	$-$$	$
Insulated	• No supplemental heat needed to keep from freezing • Widely available, many brands	• Minimal water usage required to keep from freezing • May be damaged if allowed to freeze • Often installed on a concrete pad	$$-$$$	$
Movable	• Relatively inexpensive • Can supplement other water sources during periods of high water usage (additional animals) • Easily moved • Provides on-site water storage • Useful in emergency situations	• Short to moderate life span	$-$$	$$
Bottomless	• Large capacity at relatively low cost • Provides on-site water storage • Long useful life	• Level site required • May need contractor for installation	$$-$$$	$
Limited Access	• Simple and inexpensive • Reduced bank erosion • Reduced sediment and nutrients entering water	• May require additional fencing • Few appropriate locations for installation • Requires annual maintenance	$$	$$
Hardened Surface	• Adaptable to stream size and location • Allows livestock and vehicle crossing • Low maintenance	• Expensive • Requires suitable locations along stream • Requires annual maintenance • Requires specialized grading • Requires engineered design	$$$	$$

Hardened Surface

Overview

To avoid mud around permanent tank locations, the space around the tank should be protected by a hard surface (concrete) or hardened surface (geotextile-gravel surfacing). A larger area can be protected by combining both a concrete pad and a surrounding hardened surface.

Concrete is an excellent long-life surfacing material. Soil cement or fly ash can be a less expensive option for providing a durable hard surface, but with a shorter life than concrete.

Geotextile covered with layers of gravel provides drainage through the surface as all materials are porous. Two-inch diameter gravel provides a firm base but is uncomfortable enough that cattle won't linger by the water and destroy nearby vegetation.

Movable tanks that are frequently relocated to avoid the development of a high-use area with damaged vegetation and mud may not need a hardened surface.

Hardened surfaces can also be used in other high-use pasture areas such as winter feeding sites to avoid mud buildup.

Advantages

- Can be used around a wide variety of livestock waterers, both existing and new.
- Water drains away from the waterer rather than pooling at the base.
- Can be used for winter feeding sites as well as around waterers.
- Allows easier removal of any manure buildup.
- Improves runoff water quality.
- Can combine concrete and hardened surface to protect a larger area at a more moderate cost.
- Improves livestock performance by avoiding losses attributable to mud.

Limitations

- Must be periodically maintained with additional gravel.
- Some site preparation may be necessary where ground is not level.

Design Considerations

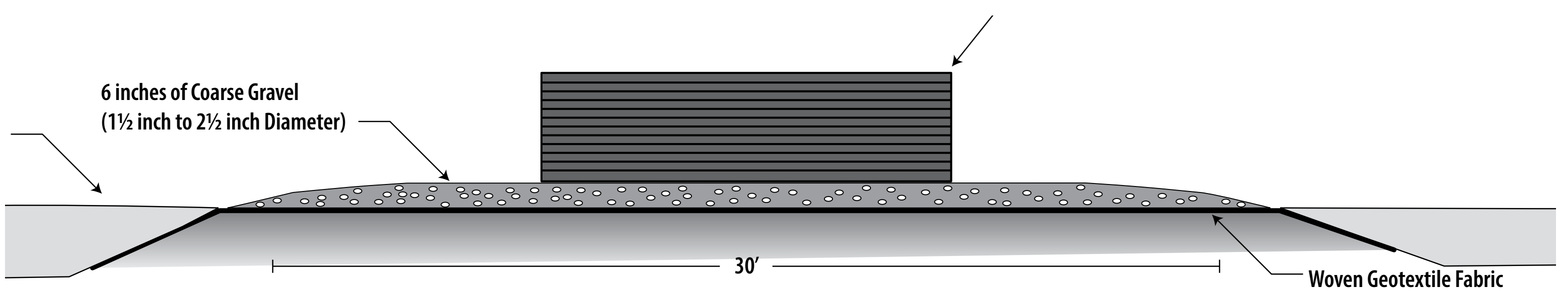
Locate hardened pads on firm soil, first scraping to remove all vegetation, roots, and rocks. Grade the site to slope ¾ to 1 inch per foot away from the waterer. The recommended minimum width of a hardened surface around a waterer is ten feet.

Unroll the geotextile directly on the soil where it will be installed. Overlap strips of geotextile by at least 18 inches. Remove wrinkles but do not stretch the fabric. Cover the geotextile with rock within 48 hours of installation to avoid textile damage due to sunlight.

Cover the geotextile with a 4-6 inch layer of coarse gravel and then add a 2-3 inch layer of finer aggregate (not as fine as sand). Do not drive directly on the geotextile during rock installation.

When combining a hardened surface with a concrete pad, the hardened surface should extend at least two feet under the edge of the concrete.

Maintain the hardened surface by periodically removing manure and feed and reapplying fine aggregate before the lower layer of rock is exposed.



Hardened Stream Crossing

Overview

Properly designed and installed hardened stream crossings provide a safe, permanent area for livestock and equipment to cross streams without becoming bogged in the mud, and they protect the streambanks and streambed.

Advantages

- Adaptable to various stream sizes and locations.
- Quick installation.
- Long useful life.
- Low maintenance but rock layers will need to be periodically renewed.
- Does not obstruct or impair stream flow.
- Encourages livestock to use stream water at desired location, especially when combined with fencing.
- Does not require poured concrete.
- Reduces erosive livestock trailing down to the stream.

Limitations

- Can be expensive if gravel delivery costs are high.
- Stream down-cutting can damage the crossing.
- Requires grading and may need a professional design.

Design Considerations

Crossings should be placed on riffles, never in pools, and should be placed perpendicular to stream flow. The design includes approach ramps on both sides of the stream and the in-stream portion of the crossing. Approach ramps are created by grading the streambanks to a uniform slope from the top of the bank to the level of the stream.

After grading, geotextile fabric is laid over the soil and streambed surface, from the top of the approach ramp, through the stream, and up the approach ramp on the other side. The geotextile is then covered with layers of rock and gravel.

The final streambed crossing surface should be at the same elevation as the original elevation and should smoothly grade into the approach ramps. The stream bed will need to be excavated to accommodate the thickness of the geotextile fabric and gravel fill material.

This practice may require permits. Please read the permit section of this handbook.

Locating Water Access Sites

The location of a watering site influences herd behavior and drinking patterns. Animals tend to drink one at a time if the pasture size is 10 acres or less.

If water is further away, animals will travel as a herd to drink. Concentration of livestock loitering around a water source can lead to development of a "sacrifice" area devoid of vegetation and prone to muddy conditions and manure-contaminated runoff unless a protective hardened surface is installed. Mitigate runoff between the sacrifice area and nearby streams with a 100-foot buffer of grassy vegetation.

Boss animals may prevent timid animals from drinking enough water, as the entire herd may move off before there is sufficient time for the last animals to fully drink. At least 10% of the herd should be able to drink at the same time.

Water, feed, minerals, and shade all attract grazing livestock. Locating these attractants throughout the pasture rather than siting them adjacent to each other can minimize the development and size of sacrifice areas.

Limited Access

Overview

Ponds and streams are common sources of livestock water, but allowing unlimited access can cause severe bank erosion, poor water quality, and other related problems. Livestock prefer clean water and avoid steep or muddy approaches to water whenever possible. Water access sites built with hardened surfaces and fencing can minimize many of the direct access concerns.

Advantages

- Improved livestock safety and health with less foot rot and fewer leg injuries
- Reduced bank erosion
- Reduced sediment and nutrients entering the water
- Extended pond life
- Applicable to both new and existing ponds
- May increase livestock water intake and improve livestock weight gains

Limitations

- Fence maintenance is required after flood events or when the water level is lower than the fence
- No suitable installation sites may be available for some ponds or streams, especially large streams with variable flows

Design Considerations

Hardened access ramps or walkways should have a maximum slope of 6:1 (17%) run to rise. While ramps as steep as 4:1 have been installed, flatter slopes of 8:1 to 20:1 are preferable where space allows, as livestock prefer milder slopes and access is less treacherous in icy conditions. Sides of the ramp should be 3:1 if the site conditions are favorable.

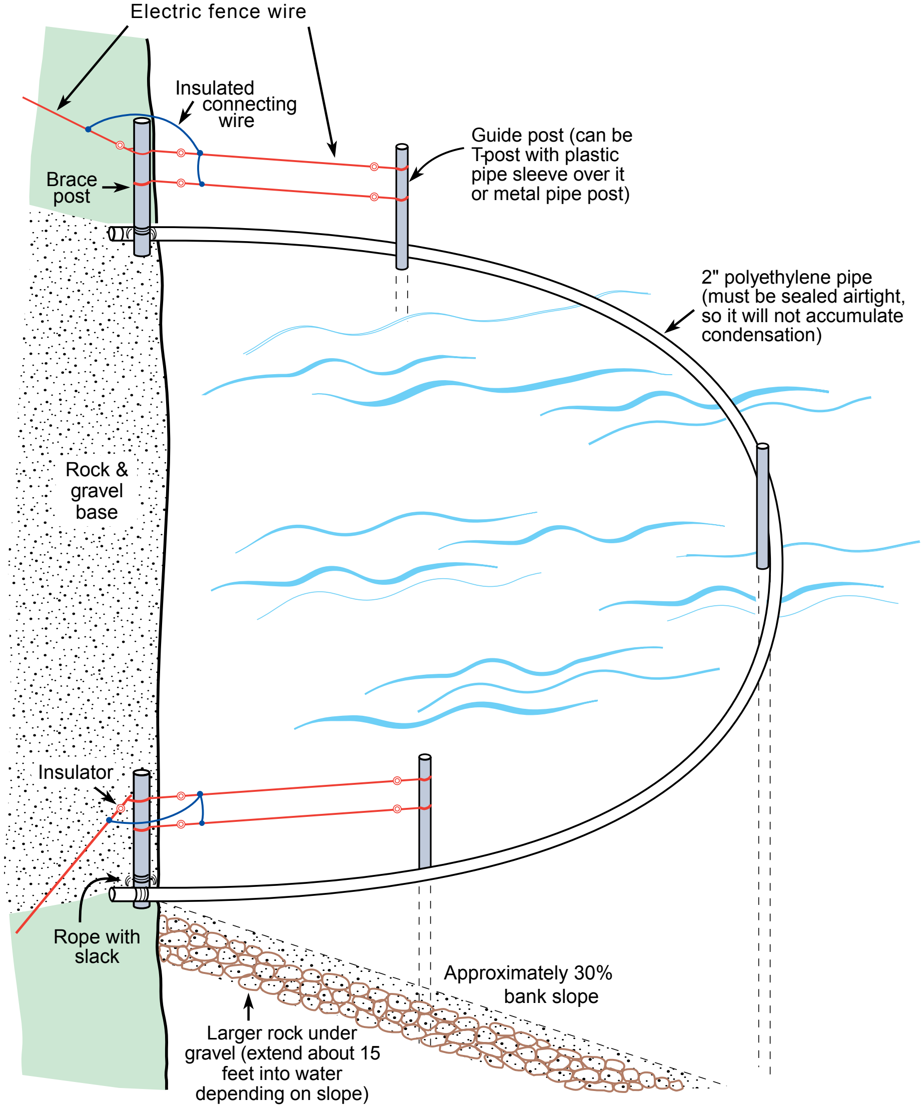
Width of the hardened access may vary, with widths of 10 to 80 feet. The recommended width of the water access can be calculated using a starting width of 10 feet and adding an additional foot of width for each 10 cattle. For example, for a herd of 50 cattle, the recommended width would be 10 + (50 ÷ 10) = 10 + 5 = 15 feet wide.

The ramp surface is comprised of compacted, non-slip gravel, concrete, or crushed rock. Semitrailer or car tires can be embedded in the ramp to help hold the gravel in place. If several sizes are used, place larger tires near the bottom of the ramp. A gravel size of 2 inches will allow livestock to easily walk on the ramp but discourages loafing.

Fencing that excludes livestock from other parts of the pond or stream can be desirable to discourage congregating and loafing in the water on hot days. A floating fence that adjusts to fluctuating water levels can be made with PVC pipe.

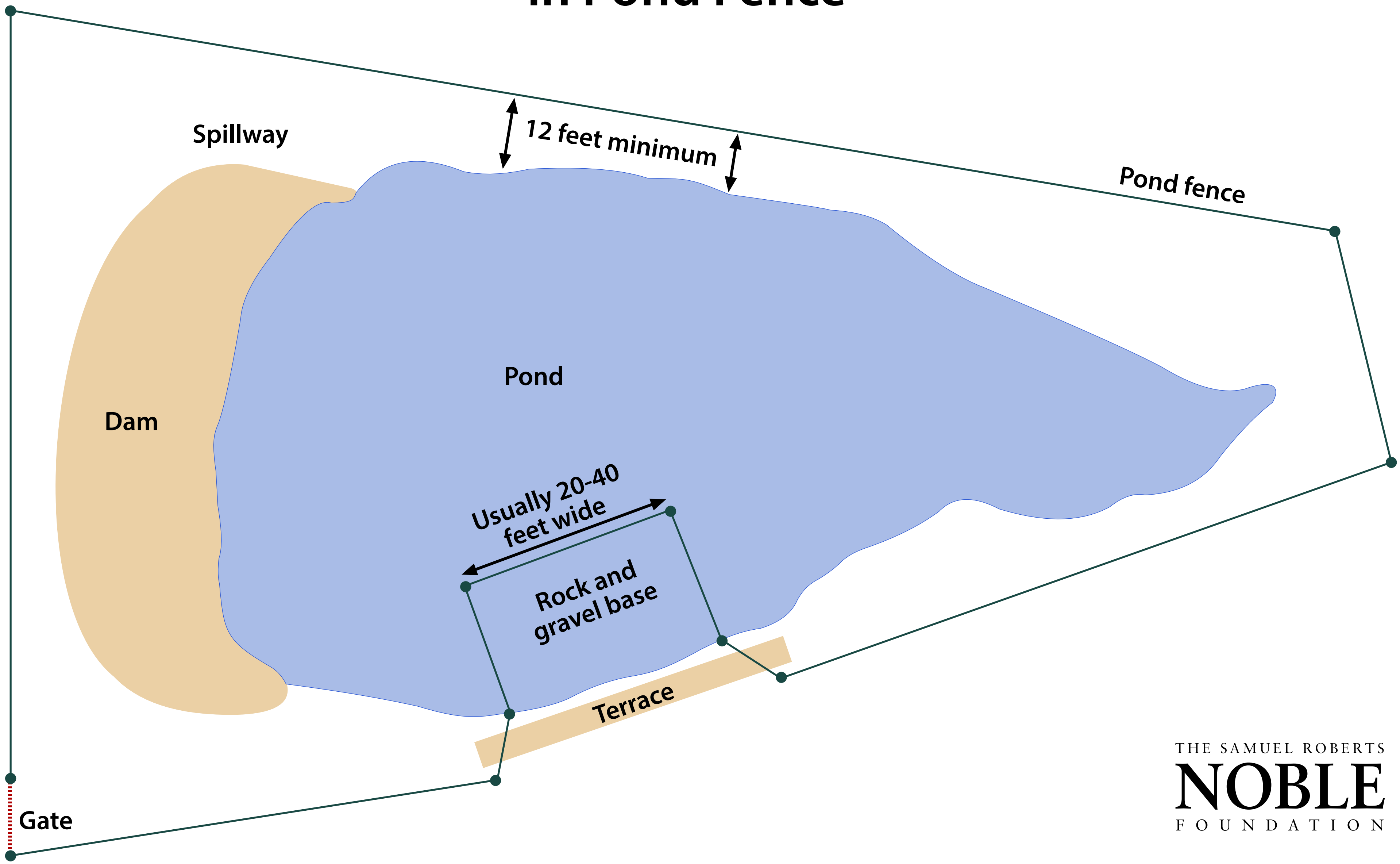
This practice may require permits.

FLOATING POLYETHYLENE PIPE FOR LIVESTOCK WATER ACCESS AT A FENCED POND



M.D. Porter and C.K. Ly 1997. Samuel Roberts Noble Foundation, Ardmore, Oklahoma 73402
NF-GE-97-01

Livestock Water Access Point in Pond Fence



THE SAMUEL ROBERTS NOBLE FOUNDATION

Porter, M.D. and J.S. McNeill. 1996. Samuel Roberts Noble Foundation. Ardmore, Oklahoma

NF-GE-96-02

Tire Tank

Overview

Large rubber tires from heavy earth-moving, construction, or agricultural machinery can be modified into reliable livestock watering tanks that are durable and relatively inexpensive. Tires utilized for this purpose should be of sufficient depth and diameter when laid on their sides to have the desired water storage capacity. Also important is the ability to remove all or part of the upper sidewall of the tire to allow livestock access to the water. Tire tanks can be used in most locations suitable for any open-topped tank, and are relatively freeze-resistant (but not freeze-proof) during the winter.

Advantages

- Simple and relatively inexpensive
- Available in a wide variety of sizes
- Durable and non-breakable; no sharp edges to injure livestock
- Can be used with both pressurized and gravity-flow water systems
- Can use larger dimension pipeline and plumbing for faster refill rates

Limitations

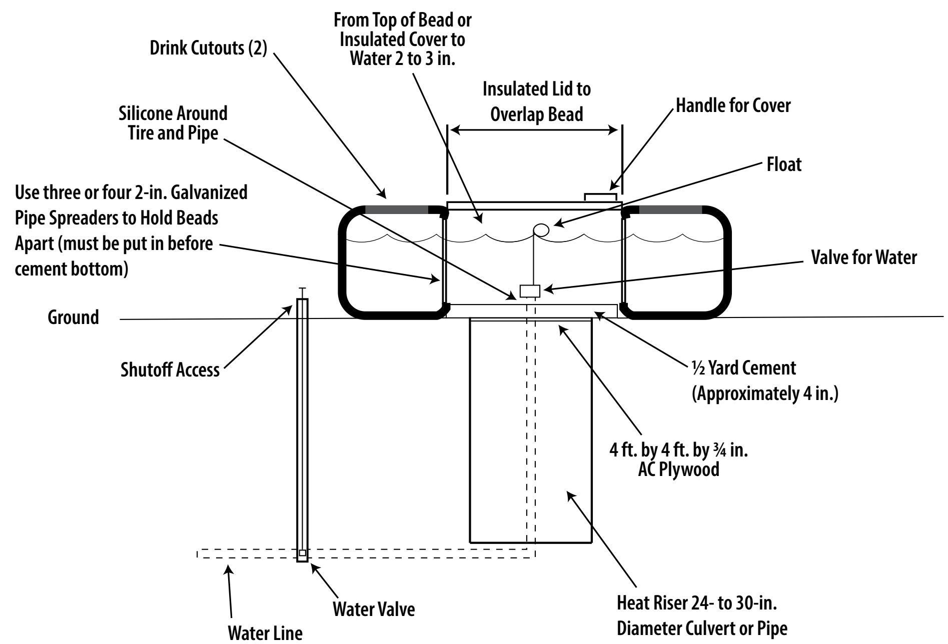
- Larger tires are heavy to handle during installation
- Larger tires and/or multiple tires may be needed for large herds
- Removing part or all of one sidewall can be difficult

Design Considerations

Most tire tanks cost a few hundred dollars. Used tires are often donated by companies using heavy equipment. Tire size should be selected based on the size of the herd to be watered. Tires used for tanks are typically 4 to 13 feet in diameter. When the tire tread is too wide (side of the tank is too high when the tire is lying on its side), the tire can be partially buried to reduce the height, which will also increase freeze protection. If the water depth in the tire will be greater than 25 inches, the producer may be advised to select a narrower tire. Minimum depth is often 12 to 15 inches in order to have adequate depth for the float system to work.

The tire sidewall is cut away either partially or entirely on what will be the top side of the tank for livestock's access to water. A heavy-duty reciprocating saw works well in most cases. Cutting holes rather than removing the entire sidewall will improve freeze resistance but limit the number of livestock that can drink at one time. Tires with the sidewall already removed are available from several suppliers.

Tire tanks are usually supplied with water by an underground pipeline from the water source Water can gravity flow from springs or ponds, or from pressurized sources such as wells or rural water supplies. A float valve is usually installed to regulate water flow into the tank. The brass nipple installed through the concrete bottom of the tank should be located so that the float is near the center of the tank. The length of the float arm may require installing the nipple closer to the side of the tank but still a few inches away from the tire bead. Water supply lines should



be a minimum diameter of one inch for pressurized water systems and two inches for gravity-flow systems. Drain and/or overflow lines should be planned to carry away excess water or prevent freezing and are also helpful when cleaning the tank.

The tank bottom is sealed with concrete, bentonite, or other heavy clay to prevent leakage. Another sealing option is to use a heavy metal or plastic plate screwed to the tire.

A layer of geotextile fabric laid on the soil under the tire before tank installation can be covered with a 6-8 inch layer of coarse gravel around the tank to create a protected heavy-use area that provides a durable, hardened surface that reduces muddy conditions. Installing a deck of used railroad ties adjacent to the tank gives small calves access to water when the tank sides are high. A protective railing over or around the tank keeps livestock from wading or being inadvertently pushed into the tank and helps protect the piping and floats in the tank.

Concrete Waterer

Overview

Concrete waterers are reliable and durable. They can be installed as part of gravity-flow or pressurized systems. The heavy-use area around the waterer can be protected with a geotextile fabric and gravel surface to reduce erosion and mud. Some models allow two pastures to be watered with one fence-line installation.

Advantages

- Can reduce or eliminate direct stream and pond use by livestock.
- Livestock often prefer to drink from a trough rather than directly from live water.
- Can be used with both non-pressurized (gravity flow) and pressurized water sources.
- Long useful life.
- Can be installed to resist freezing.
- Low operational costs.
- Improves water quality and health of pond when used in conjunction with pond fencing.
- Minimal maintenance requirements.
- Producer can install.
- Multiple concrete waterers can be plumbed into one waterline if enough elevation or water pressure is available.
- Does not require a poured concrete pad.
- Many models to choose from.

Limitations

- Tanks are heavy, weighing between 2,300 and 3,000 pounds each.
- Shipping costs may be high.
- If a pond is the water source, a livestock water pipeline under, through or around the pond dam is required.

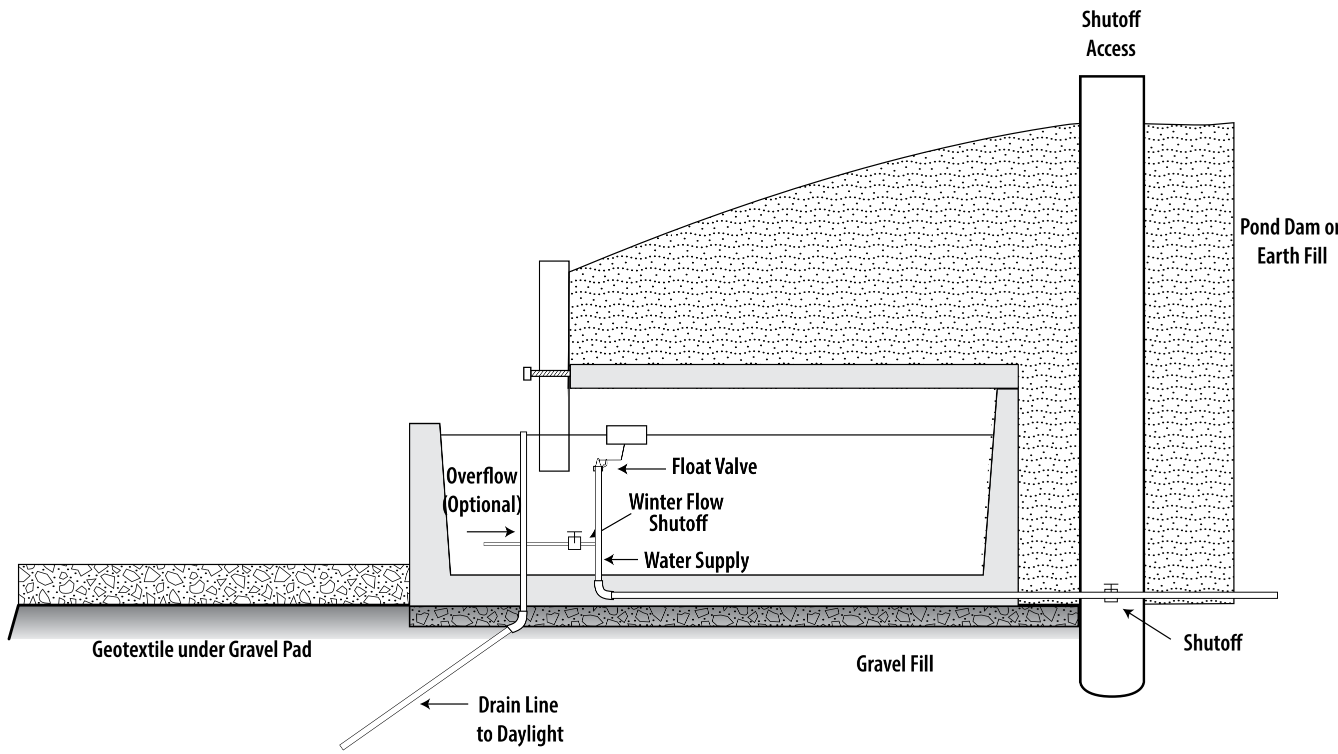
Design Considerations

The waterer should be placed on a well-drained gravel or sand site that offers protection from the wind if the waterer will be used during the winter. The site should include a hardened surface area of about 15 feet square in front of the waterer where cattle stand. The pad area can be constructed with geotextile fabric topped with a 6- to 8-inch layer of 1- to 2-inch gravel.

The waterer should be located so that the full water level in the tank is at least 4 feet (preferably 6 feet) below the water level in the pond for adequate gravity flow. The pipeline should be buried below the frost line. After waterer installation, soil is piled around the sides and on top of the rear of the tank baffle to prevent freezing. When possible, the back of the tank behind the exposed water drinking surface should be protected from livestock traffic.

A pond water supply pipeline can be placed either under the dam (new pond construction), or through the dam (existing pond). It is very important to seal the space around the pipeline, especially the area closest to the water edge. The seal can be constructed of compacted clay, an anti-seep collar or bentonite clay.

Installation instructions can be obtained by contacting your watershed specialist or obtaining the K-State Research and Extension publication *Alternative Livestock Watering: Covered Concrete Waterer*, MF2737, July 2006.


Shutoff
Access
Pond Dam or
Earth Fill
Float Valve
Overflow
(Optional)
Winter Flow
Shutoff
Water Supply
Geotextile under Gravel Pad
Gravel Fill
Shutoff
Drain Line
to Daylight

Insulated Waterer

Overview

Keeping water ice free is a challenge for livestock producers in colder climates. Heating elements or gas burners installed in tanks to prevent freezing are often problematic. Waterers designed from molded plastic with high insulation values* provide liquid water for livestock during the winter in the central United States without the use of auxiliary heating.

*(R-factor – resistance to heat flow)

Advantages

- No need for supplemental heat to prevent freeze-up.
- Available from local farm supply stores.
- Availability of parts is good.
- Livestock learn to use them easily.
- Do not rust.
- Use UV-resistant molded plastic to reduce solar degradation.

Limitations

- Require frequent checking during inclement weather.
- Can be damaged if allowed to freeze repeatedly during periods without livestock use. Livestock herd winter water requirements should be matched to waterer size to ensure three or more complete water changes/day in the waterer.
- Generally, requires a concrete pad base.

Design Considerations

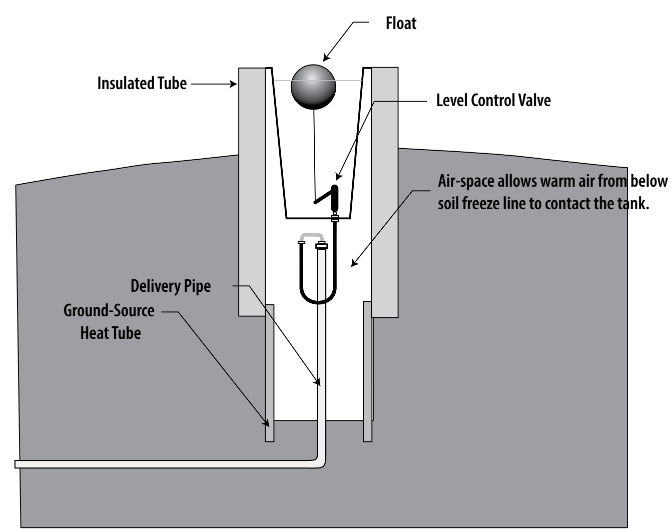
Insulated waterers rely on warm recharge water from the pipeline feeding the waterer to prevent freezing. To prevent freezing in the central U.S., most companies recommend at least 10 to 15 animals per waterer space or opening to ensure that the herd drinks two or three volumes of water per day on very cold days, allowing the waterer to refill with warmer water. Placing the waterer in a fence line can allow more livestock to use a waterer.

The combined heat from a vertical "earth tube" installed in the ground below the waterer and the above-freezing temperature of an underground water source is generally sufficient to prevent ice from forming inside the waterer. Water sources that are colder than groundwater, such as ponds and streams, increase the chances that the waterer will freeze.

Waterer covers help retain the intrinsic heat of the water and seal out cold air and wind. Typical covers are large balls that float tightly against the inside of the tank opening, or doors that the livestock open to reach the water. Occasionally these doors or balls will freeze shut; a bump or tap by the producer will open the door or dislodge the ball. Livestock learn how to access the water.

Ideally, insulated waterers should be placed in a sunny location protected from wind and snow to minimize heat loss and reduce the chance of freezing. Producers should check the waterer twice a day in cold weather: once in the morning to make sure that livestock can access the water, and again near evening to be sure the float and valve are operating properly.

Most insulated waterers require a solid base such as a concrete pad. Recommended installation includes a hardened surface around the concrete pad.



Movable Tanks

Overview

Movable tanks are temporary watering sources especially adapted for watering livestock in rotational or cover crop grazing situations. Movable tanks are generally constructed from lighter-weight materials than more permanent watering structures and are smaller to make them easier to relocate. Typical materials include galvanized steel, fiberglass, structural foam and plastic. The initial cost of movable tanks is generally less than for more permanent tank installations. As with all tanks, movable tanks should be sized for water demand.

Advantages

- Allow utilization of forages in locations away from more permanent water sources.
- Useful when hauling water to livestock that are grazing crop residues.
- Improved water quality compared to direct pond access.
- Provide supplemental water source for increased herd size or improved grazing distribution.
- Easily relocated to prevent mudhole formation around the tank due to heavy use.
- Initial cost is often lower than for permanent waterers.
- Adapted for use with above-ground water supply lines during freeze-free weather.

Limitations

- Empty and unsecured tanks may blow away easily due to small size.
- Small tank size may require a water supply with a rapid refill rate to meet livestock demand.

Design Considerations

Movable tanks should be sited so that water drains away from the tank to avoid mudhole formation. Level the site if necessary and remove any rocks that might puncture the bottom of the tank.

When using a pressurized water supply, install a shutoff float or arrange an overflow device to gravity drain the water to a low spot or ravine at least fifty feet from the tank.

Select a tank size that meets the needs of the herd size and the refill rate, which may be limited by the size of temporary water supply hookups, such as watering hoses. Also consider the dryness of the forage (crop residue) being consumed, which can increase livestock's water needs.

Bottomless Tank Waterer

Overview

Bottomless tanks are high volume, open-topped tanks used both for storing water and watering livestock. They are often made of corrugated metal sections, such as grain bin sections, bolted together to form a large circular ring on site. A bottom is constructed inside the tank after it is assembled and placed in position. The bottom is usually made of bentonite clay, concrete or plastic membrane.

Because bottomless tanks come unassembled, very large (20 feet or larger diameter) tanks can be assembled. Tanks this size would be prohibitively expensive to ship if they were preassembled. Because of their water storage capacity, these tanks can compensate for the variable water output of windmill and solar panel systems, assuring an adequate supply of livestock water at all times.

The large size of the tanks allows them to be utilized for water storage in gravity fed water systems as well as allowing livestock to drink directly from the tank.

Advantages

- Simple construction.
- Easily adaptable to most sites.
- Large capacity at comparatively low cost compared to other tanks.
- Can be constructed with on-farm labor.
- Serves as both water storage and drinking device.

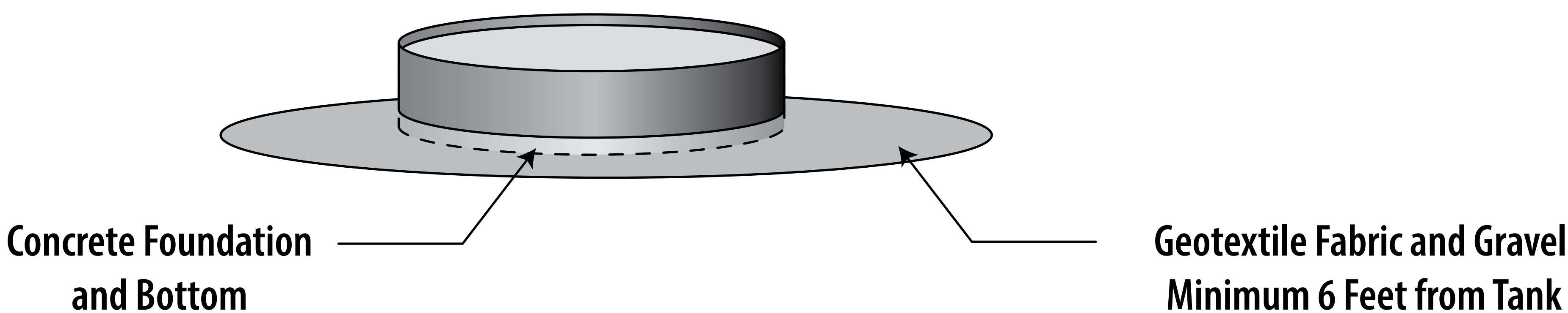
Limitations

- Tank will eventually need to be rebuilt due to soil-structure properties.
- Livestock may attempt to stand in the tank.
- Difficult to relocate, will require much time, effort and expense.

Design Considerations

Bottomless tanks are generally 25 to 30 inches deep and 20 feet or more in diameter. The lower part of the tank wall is embedded into the tank bottom material.

The tank bottom is susceptible to soil shifting and to changes in soil temperature and moisture. Minor maintenance is required on a regular basis. With substantial effort, tanks can be disassembled, moved, and reassembled at another location.



Grazing

Grazing Management for Water Quality

Grazing lands can provide excellent vegetative cover for precipitation infiltration and soil water recharge. Grazing lands can also be a source of sediment, fertilizer, pesticide, and manure pollutants when they are not properly managed, impairing the water quality of streams, rivers, reservoirs, and ponds.

Grazing management that protects water quality is based on two objectives: 1) promote the healthy growth of desirable plants to maintain a vigorous vegetative cover that intercepts raindrops, reduces runoff, and facilitates root and soil microbial growth to bind soil particles together; 2) reduce the potential for surface runoff that moves or leaches sediment, nutrients, animal wastes and pesticides into water sources. Sediments can carry nutrients with them as they erode into water sources.

Riparian areas adjacent to streams and watercourses are critical areas for protecting water quality. Comprising only 1 to 2 percent of Kansas grazing lands, they play an important role by trapping or transforming pollutants. Mismanaged grazing, especially overgrazing, in riparian areas can damage or destroy the vegetative cover critical to maintaining good water quality. Vegetation in riparian areas is prone to overgrazing because it greens up earliest in the spring, remains green longer into the summer due to a higher water table, and provides livestock with easy access to both water and shade in the same location. Extended periods of riparian grazing can also result in the formation of erosive cattle trails down steep banks, along with manure and urine deposition in or very near the water, which increases pathogens, nitrate, and phosphorus in the water.

Management Principles

Uniform grazing distribution may best utilize forage resources. Grazing patterns are established very soon after livestock enter a pasture. Placement of attractants such as water, salt/mineral supplements, shade, and feeding sites help determine grazing patterns.

Livestock water is a key attractant, and encouraging livestock to move away from riparian areas and pond edges is important to protect water quality. Restricting access and providing alternative drinking sources are typical strategies to reduce the time livestock spend around open water.

Fencing all or part of the open water source can be used to restrict livestock access in either time or extent. Fencing can be permanent or temporary, such as electric fence. Virtual fencing may be used to provide close control of livestock movement for temporary access to open water and riparian grazing. A rotational grazing strategy that moves animals often enough to maintain forage quality and cover is also an option. Rotations may involve as few as two pastures. Any time animals are restricted from using the primary water source, an alternative water source must be provided.

Grazing lands should be managed using good principles of grazing management. Vegetation defoliation should be followed by periods of rest, allowing the plants to recover. Grazing management can be complex when all factors are taken into consideration.

Multispecies Grazing

Each livestock species has preferred drinking options, levels of acceptable concentrations of nutrients or toxins in the water, and specific daily water intake requirements (see Table 11).

Sheep and Goats

The use of sheep and goats with cattle in multispecies grazing systems provides benefits while minimizing the risk associated with raising a single species of livestock. One of the greatest benefits is in maintaining healthy vegetative cover in pastures while maximizing forage utilization due to differences in grazing preferences. Cattle graze mostly grass with some forbs (non-grass herbaceous plants such as wildflowers). Sheep graze more forbs than grass. Goats graze browse (tender tips of woody plants such as shrubs) as well as some grass and forbs.

Automatic waterers and tanks may need adjustments to allow sheep and goats to reach the water. Tanks that are 10-12 inches in height will not need modifications for sheep and goats of all ages, while waterers with moderately taller sides (up to 18 inches) can be accessed by adult animals. Waterers and tanks higher than 18 inches will need modifications to allow sheep and goats to reach the water. Planks, cross-ties, cement blocks, poured cement skirt, or similar materials placed near waterers for animals to stand on in effectively reduces the height of the tank.

Water quality that might be safe for cattle may be unsafe for sheep and goats, as much smaller concentrations of harmful substances can be tolerated (Table 11). While cattle must often be physically restrained from standing in water, sheep and goats tend to be averse to standing or even walking in water.

Sheep and goats will consume 0.5 to 5.5 gallons of water per day depending on ambient temperature and water intake from snow or dew present on grazed vegetation. Optimal water temperatures range from 44 to 55 degrees Fahrenheit. Sheep tend to stay congregated in herds, so waterer refill rate needs to be adequate to allow all animals to drink at each visit.

Guard Animals

Predator management is one of the most important considerations when adding small ruminants to a cattle operation, with coyotes, the primary predator, of most concern. Guard animals, along with fencing and other control strategies, are used to protect against predators.

The most popular predator control measure is the guard dog. There are many breeds of dogs that can effectively act as guardians (Great Pyrenees, Anatolian Shepherd, Kangal, Maremmano-Abruzzese, Akbash, Komondor, Central Asian Shepherd, Karakachan, and many more). Guard dogs are typically very effective, especially when they are raised with the livestock they are protecting. Cattle can also benefit from guard dogs.

Guard dogs have different diet requirements than ruminants, increasing management needs. Dogs need about 1 ounce of water for each pound of body weight. For example, a Great Pyrenees mature male averages about 110 pounds, and needs about 0.86 gallons of water daily. Dogs can use the same water sources as cattle. Tank height adaptations may be needed as described above, or dogs may jump into the tank to reach water, which is undesirable. Dogs should be introduced to the water sources they will be using when they are first placed in a pasture.

Llamas and burros have similar diet requirements to small ruminants, but llamas will need periodic shearing and burros will need hoof trimming. Llamas and burros react less consistently to the livestock they are guarding. Intact males of both species can be too aggressive to provide adequate guardianship.

Llamas and alpacas need 2 to 5 gallons of water per day and can utilize the same water sources as cattle. While able to survive on less water, it is good management to provide adequate water. Burros and donkeys need 4 to 8 gallons of water per day depending on exertion level.

Horses

Horses drink more water with higher ambient temperatures and more strenuous activity. Average consumption is 5 to 15 gallons of water per day. Dehydrated horses will need electrolytes in addition to water as they rehydrate. Horses, like other grazing animals, consume some water from lush vegetation, but they also need free water sources. Water consumption needs increase when horses are fed dry hay, or during pregnancy and lactation.

Horses are not as prone to nitrate toxicity as cattle, with a limit around 450 ppm. Horses benefit from the calcium in water with a high pH.

Table 11. *Salinity ranges for different livestock species (total dissolved solids (TDS) in mg/L).*

Livestock	Acceptable Range	Initial Reluctance to Drink, but may Adapt with Limited Reduction in Production	Loss of Production and Decline in Animal Condition and Health
Beef cattle (mature on grass)	0 – 4,000	4,000 – 5,000	5,000 – 10,000
Beef cattle (feedlot)	0 – 4,000		>4,000
Dairy cattle (dry)	0 – 2,400	2,400 – 4,000	4,000 – 7,000
Dairy cattle (milking)			3,500
Sheep (mature on pasture)	0 – 4,000	4,000 – 10,000	10,000 – 13,000
Sheep (weaners, lactating, pregnant)	0 – 4,000		6,600
Horses/Equine	0 – 4,000	4,000 – 6,000	6,000-7,000

Reference

https://www.agric.wa.gov.au/livestock-biosecurity/water-quality-livestock

Acknowledgment: Alison Crane

Water Systems for Grazed Cover Crops and Crop Residue

Livestock watering needs should be considered when planning to graze cover crops and crop residue. Combining livestock and cropping operations has both benefits and challenges. Electric fence installation is often necessary. Cattle will compact the area around water sources in crop fields. Consider placing watering tanks in areas that have low yields or are already compacted, or regularly move tanks to avoid compaction.

Livestock watering systems on grazed cropland can be temporary, semi-permanent, or permanent.

Temporary systems generally involve hauling water from off-site (see Hauled Water chapter) to movable tanks. Place tanks where they can be easily accessed by the water hauling vehicle. Select hauling equipment (pickup, truck, trailer, semi) that can get to the tanks under all road and field conditions (ice, snow, mud). Tanks mounted on sleds or trailers (Photo 7) a can be easily pulled from paddock to paddock. Flexible hose on a reel can be used where needed to deliver water from the hauling vehicle to the waterer. A continuous flow system with a simple float and

Photo 7. *A simple sled makes moving a tank easier. (Farm Show: used with permission.)*

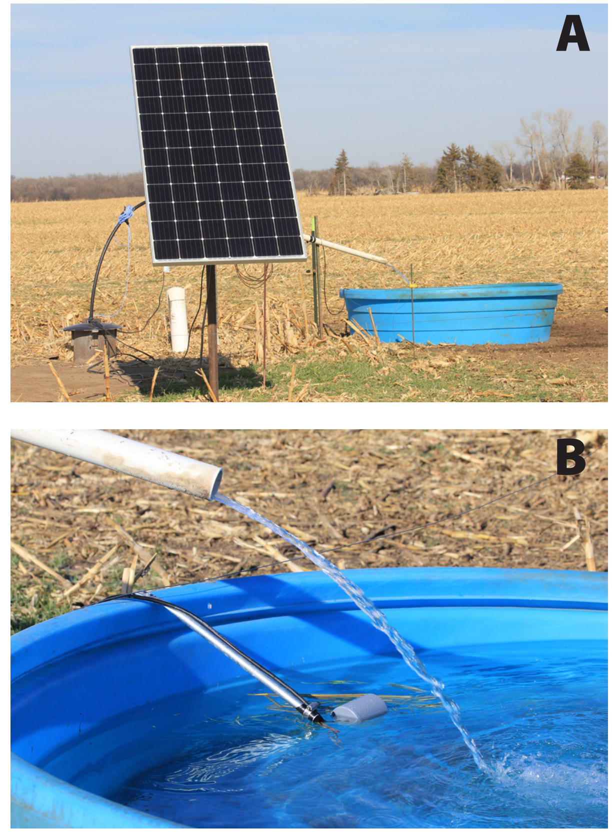


Photo 8. *Solar pumping system in a cornstalk residue field that was no-till drilled with rye.*
Photo 8a. *System consists of large permanent mounted solar panel that provides power to the pump that pulls water from the water well and into the blue water tank that has a float switch. Well and pumping systems have protective fencing.*
Photo 8b. *Closeup of the float switch included in the solar water pumping system on cropland.*

Photo 9. *Solar pumping system with well at edge of crop field.*

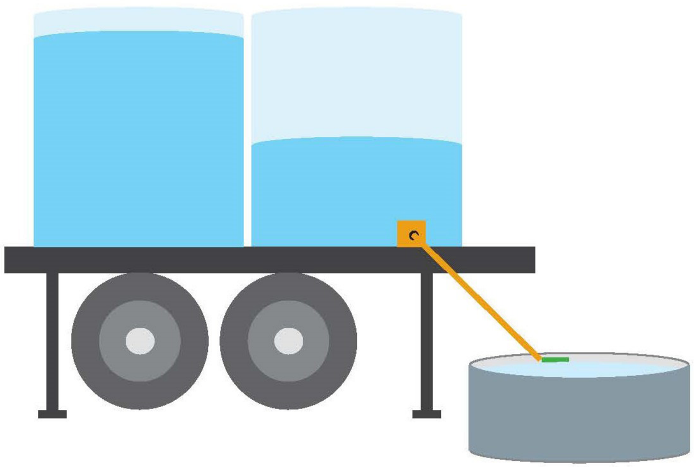


Figure 3. *Water tanks mounted on a trailer can be situated near the tank site to provide extra water storage. A pumping system can be added to the trailer to move water to a tank at higher elevation if needed.*

tank overflow system that directs water away from the trough can be used during freezing weather.

When the same crop fields are grazed every year, greater investment can be made in the watering system. The economic feasibility of installing a more permanent water supply is improved when the system serves multiple fields or pastures.

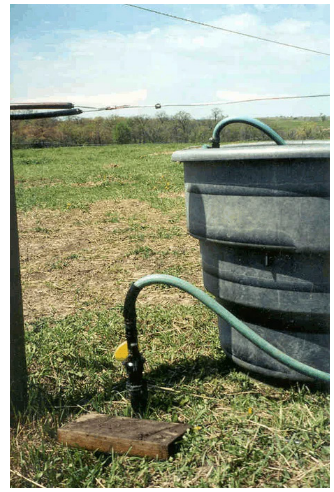


Photo 10. *VCR riser and quick coupler combination provide easy connection and shut off points for hoses. (PowerFlex Rotational Grazing Supply: used with permission.)*

Semipermanent systems include a permanent water source on or near the crop field such as nearby wells, existing ponds, and streams.[1] The remainder of the watering system (pump, pipe, tank, and float and supply lines) can be moved as needed for planting a crop. These systems generally connect to movable stock tanks to supply water to livestock. Typical pumps for semipermanent systems include trailer-mounted solar pumps or electrical pumps where on-site electricity is available (see pumping chapters). Examples of solar pumping systems using well water are illustrated in Photos 8 and 9.

Large storage tanks on trailers can be used in a semi-permanent watering system as illustrated in Figure 3. Placing storage tanks on a trailer allows them to be removed from the field when not needed or used for other purposes. Storage tanks reduce the risk of running out of water during periods of cloudy weather when solar pump capacity is reduced, or when adverse conditions interfere with hauling water. Storage tanks are subject to freezing, especially near the inlet and outlet valves and piping. The larger the tank the less chance of the water freezing.

Permanent systems may be the best option for cropland you own and plan to graze every year, especially if there is an existing or easily developed water source nearby, or connection can be made to a rural water district supply line.

Subsurface waterlines with risers and quick couplers can be installed to transport water from the source to the waterer. Risers are generally located in field margins or along permanent fences where they will not be damaged by field operations (Photo 10).

A wide variety of waterers can be selected as the plumbing is permanent. If the field is generally grazed during the winter, select a waterer type that is resistant to freeze damage or has enough water flow to remain unfrozen. An example of a permanent waterer placed on cropland is shown in (Photo 11).

Photo 11. *Permanent freeze resistant waterer in field of rye.*

Water Supplied through Lush Forages

Total daily water intake of animals includes not only free-water drinking sources, but includes the moisture in feedstuffs such as green wheat and high-moisture concentrates. While, in theory, a large portion of livestock water needs could be met by consuming high-moisture annual forages, drinking water also needs to be supplied to avoid suboptimal animal performance.[2] Additionally, as the plant matures or becomes stressed due to drought or other weather effects, the water content of the plants declines. In general, forage moisture content is highest early in the grazing period.

Source

1 Williams, A. (2018). Water Systems for Grazing Cover Crops. In M. Filbert , K. Solberg, P. Huff, E. Spratt, & K. Vergin (Eds.), Grazing Cover Crops: A How-To Guide (p. 32). Arlington, Virginia: Pasture Project.

2 Garcia, T. J., M. Menhini, J. Jeffus, and R. R. Reuter. 2022. Does drinking water availability affect stocker cattle grazing wheat pasture?. J. anim. Sci. 100:37. https://doi.org/1.1093/jas/skac028.071

Remote Monitoring of Livestock Watering Devices

Remote monitoring devices allow managers to monitor the water supply in multiple, often distant locations, saving both time and travel expense. Remote monitoring is often used with watering tanks.

Game cameras can be positioned near a tank so that a photo of the water level can be captured at specified times and transmitted to a programmed cell phone number. Game camera systems are reliable, low cost, and can also reveal problems such as a failed pump or leaking tank. Cellular service is required at both the game camera location and the cell phone location for photo transmittal. For best results, manufacturers recommend at least three bars of cellular strength for proper functioning. Some companies offer photo storage on an associated website for both computer and phone viewing. Camera settings should be set to take photos at specific times during the day rather than relying on motion activation, thus reducing the number of photos taken and stored.

Pressure transducers powered by a solar panel transmit the depth to the company data base. The information is available by phone app or computer. Warnings are sent by text messages or phone notification reporting the water level. Water level is assessed every 2 hours. Alerts are sent if the water level drops below the predetermined level. Pressure transducer systems do not provide a visual confirmation of the water level. Some companies use cellular transmission, which requires cell service at both the sending and receiving locations. A related technology uses satellite transmission for areas without cell service and can report at varying time intervals as determined by the operator.

Cost, features, frequency of data transmission, and the operator's comfort with the technology are important considerations when selecting a remote monitoring system. Peace of mind associated with knowing that livestock have water is as important as the economic and labor savings.

Planning for a Disaster — Emergency Water

Drought

When rainfall drops below well below normal, even reliable water sources may fail. Shallow wells, springs, streams and ponds can go dry. Drought planning can begin in conjunction with the development of alternate livestock watering sites.

Eliminate livestock access to ponds with exclusion fencing and provide a gravity-flow waterer below the dam to reduce erosion, maximize pond water storage, and extend the useful life of the pond.

Conserve available water. Livestock with direct access to water not only drink water but also carry water out of the pond on their coats and stomp it into mud around the pond edge where it eventually evaporates without providing any benefit.

Connect to off-site water source. When the livestock water supply in a pasture is questionable at best, installing a frost-proof hydrant connected to an off-site pressurized water source such as domestic water can provide livestock with an assured source of water when needed.

Connect to public water supply. Most rural water districts will allow a connection to supply water to livestock but will also mandate a backflow preventer to keep livestock water from re-entering the public water supply. An **air gap** prevents backflow by creating a physical gap between the public and private water lines. The backflow preventer cannot be located where it might be submerged and must have a minimum of a 1-inch gap between the public and private lines.

Haul water. Hauling enough water to supply a livestock herd during the summer heat can be expensive and time consuming but may be the only option available other than removing livestock from the pasture. Costs include not only purchasing the water, but also the cost of a truck or trailer with a water transfer tank, storage tanks, tanks for livestock drinking, valves and hoses to connect storage tanks and drinking tanks, plus fuel and wear and tear on the equipment.

Borrow water. A friendly upstream neighbor with a large pond or flood storage watershed dam may, upon request, voluntarily release water into a stream for your livestock to use. In Kansas, compelling a neighbor to release water is difficult.

Purchase domestic water. Occasionally, grazed cropland without an on-site water supply may be located next to a neighbor's home with a reliable public water supply. The neighbor may be willing to sell water for livestock use. It is strongly suggested that instead of trying to partition out livestock and domestic use each month, the livestock producer pay the entire monthly water bill, including the minimum. Having access to the water is worth more than paying for the small amount of domestic water use included in the bill. Payment terms should be discussed and settled in advance to maintain good neighbor relationships.

Blue-Green Algae

While many types of harmless green algae exist in a pond, blue-green algae (also known as cyanobacteria) have the potential to produce toxins. Blue-green algae can produce toxins which are harmful, even lethal, to livestock when ingested. Hot, dry, still weather in summer and early autumn enhances blue-green algae growth in dugouts, ponds and shallow lakes, especially under stagnant or low flow conditions. Humans are as susceptible to cyanotoxins as animals. If a blue-green algae bloom is suspected, people and animals should be prevented from contacting the water.

Cyanobacteria micro-organisms can grow throughout the water body but often accumulate near the surface. Individual cyanobacteria are invisible to the naked eye but appear as a "bloom" when present in large numbers. The bloom may be green, olive, dark green or even purplish in color. Toxicity cannot be determined without a water test.

Blue-green algae floating on the surface of the water can be moved by the wind and can lead to a localized increase in algae density and toxin concentrations at the lee shore. Livestock drinking at these locations have a high risk of being poisoned. Calves often drink near the edges of ponds where concentrations are high, while cows with unrestricted access often wade out further from shore into deeper water and may be less affected.

Phosphorus and nitrogen enhance algae growth. Livestock's manure and urine may contaminate water, directly from the animals or from runoff.

Types of Blue-Green Algae Poisoning

Microcystin toxins are common in surface water in the Midwest, and they cause liver damage and digestive tract issues. Symptoms include jaundice, severe diarrhea, and skin lesions on teats and around eyes. After recovery from poisoning, animals may still have liver lesions that impair performance, particularly when under stress such as winter conditions. Symptoms may appear within a few hours to a couple of days after ingesting the toxin.

Other types of toxins affect the nervous and muscular systems and act more rapidly, often within 30 minutes after ingesting the toxin. Symptoms include twitching, staggering, prostration, and convulsions and may lead to death by respiratory paralysis.

Both types of toxins may be present at the same time in a body of water.

Mitigation of Blue-Green Algae

The primary method of preventing blue-green algae growth is by reducing nutrient loading in the water. Management activities such as restricting direct access by livestock and redirecting the runoff from surfaces with manure or crop fields away from the water are helpful. Grassy vegetation around banks to filter water entering the water body can be beneficial.

Using water from an alternative source is the preferred method for providing safe water for livestock when a blue-green algae bloom occurs. Copper sulfate and barley straw are potential, but less sure, methods for treating the water. The possible environmental impact and toxicity of copper for animals, particularly sheep, should also be considered before use. For a more detailed description of these control methods, refer to the Identification and management of blue-green algae in farm ponds publication in the reference section.

Once a blue-green algae bloom has formed, a water sample should be sent to a lab to check for the presence of toxins. Any level of toxin is considered unsafe for livestock, as the toxin is likely to be unevenly distributed and concentrated pockets of toxin can form within the water body.

Identifying Blue-Green Algae

While definitive identification of the exact type of algae will require a microscope, simple identification methods can be used to quickly evaluate whether you are likely to have potentially toxic blue-green or harmless green algae in your livestock water.

Test 1. A simple jar test can be used to determine if you might have harmful blue-green algae. Collect a sample of water and allow it to settle undisturbed overnight in a refrigerator. If a layer of algae forms on top of the water, it's likely to be blue-green algae. If the algae settles to a layer on the bottom of the jar, it's less likely to be blue-green algae. Senescent blooms will not float, but could still be poisonous.

Test 2. Scoop up a sample of algae from the surface of the water with a stick. If the algae looks like a coat of paint on the stick, it's likely to be one of the common types of toxic blue-green algae. If it looks more like green hair or threads, it's more likely to be harmless green algae. However, some types of blue-green algae also looks like threads. An unpleasant sewage odor and blueish or purplish tints in the water can also suggest that it is blue-green algae.

For a more complete description of the testing and interpretation methods described above, refer to the Blue Green Algae Jar Test publication in the reference section.

Testing Water Samples for Blue Green Algae

There are two tests available at the Kansas State Veterinary Diagnostic Laboratory:

1. Microscopic identification of algae or toxin quantification. Microscopic identification will determine if the algae species present in the water can produce toxins.
2. Toxin quantification. Quantifying the toxin in a water sample indicates the poisoning risk at the time and location where the sample was collected. Toxin concentration will vary over time and can differ greatly at various locations in the same body of water.

When collection water samples for testing, wear gloves e as some blue-green algae can cause severe skin irritation. Using a scoop, collect at least ½ cup of water from the surface of the pond and place the water in a clean container for shipping. Keep the sample cool or refrigerated before and during shipping, but do not freeze.

Scott, N. 2002. Algae, Cyanobacteria and Water Quality. Food and Agri-Food Canada Factsheet 590.301-3. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/livestock-watering/590301-3_algae_wq_eng.pdf

Carney, E. 2012. Blue green algae jar test. Kansas Department of Health and Environment, Bureau of Water, Watershed Planning Section incidental publication.

Van der Merwe, D., Blocksome, C., and Hollis, L. 2012. Identification and management of blue-green algae in farm ponds. Kansas State University Research and Education MF3063.

Photo 12. *Initial sample.*

Photo 13. *No blue-greens (negative).*

Photo 14. *Blue-greens present (positive).*

The Kansas Department of Health and Environment (KDHE) Jar Test Procedure

A method to indicate the presence of blue-green algae (cyanobacteria). For more information, visit *https://www.kdhe.ks.gov/777/Harmful-Algal-Blooms*

Materials

- Clear, wide-mouth jar with screw-top lid, such as a pint or quart size canning jar or a store-bought pickle jar with label removed. (Note: it will no longer be usable for food.)
- Nitrile/latex/rubber gloves.
- Plastic zip-top bag and permanent marker.

Procedure

1. Find an appropriate clear glass jar.
2. To prevent skin exposure, wear gloves while collecting a water sample from the lake or pond in question. Also avoid exposure to any scum on shoreline.
3. Collect the water just below the surface if possible.
   - DO NOT sample directly from the surface but instead just underneath, to avoid collecting only the floating scum.
4. Fill the jar two-third to three-quarters full of water (See Photo 12)
   - DO NOT fill the jar completely. Algae may give off gases that could build up pressure inside the jar, causing it to break.
   - Take site photos if possible.
5. Screw the lid onto the jar, but not too tightly.
6. Wipe off any scum that may be on the outside of the jar, or better yet, rinse the outside with clean water.
7. Place the jar inside a clean plastic bag and mark as potentially toxic if other people are likely to encounter it. Record sample location, date, and time.
8. Place the jar in a cold refrigerator and leave it completely undisturbed overnight.
9. The next morning, carefully remove the jar from the refrigerator and observe where the algae have accumulated.
   - **It is very important** that you do not shake or agitate the jar in any way. If you do, this will mix the algae into the water again, and you will not get usable test results.
10. If the algae are all settled out near the bottom of the jar, then that is a likely indication that the lake does not contain a lot of blue-green algae. (See arrow on Photo 13)
11. If the algae have formed a green ring or layer at the water surface, there is a strong possibility that the pond has a blue-green algae community present. (See arrow on Photo 14)
12. Note that this test does not provide 100% certainty. There are a few other algae that tend to collect at the surface, and there are also benthic (bottom-dwelling) blue-green alage in some systems. However, this test works well for most lakes and ponds in Kansas.

Winter Watering of Livestock

Ideally all livestock waterers would be ice-free all winter long. But most are not. Planning for watering in the winter can avoid problems when freezing weather arrives.

The water source is important when considering winter watering options. Rural water from pipes buried more than 3 feet deep will be 40 to 50 degrees Fahrenheit, which is warmer than pond water which may be near freezing. Well water is 50 to 55 degrees Fahrenheit in Kansas.

Movable stock tanks are often the most economical for summer use but can present challenges during winter use. Limiting the use of open-topped stock tanks to summer grazing areas can be an option.

Winter watering can be facilitated by using waterers specifically designed to function in freezing weather, or adding modifications that improve freeze resistance.

Super insulated tanks utilize the heat in the water entering the device from underground to keep the water temperature above freezing. No external power is needed. The highly insulated walls of the tanks combined with floating lids or balls on top of the water surface conserve the warmth of the water. Earth heat tubes that extend into the soil 4 feet or more around the incoming water line can be used to increase effectiveness. Water from wells and rural water districts is preferable to pond (surface) water in the winter due to the warmer temperature of the water entering the tank. Livestock will need to consume at least 3-4 times the volume of the water within the tank each day so that enough of the warm water refills the tank.

Concrete tanks (behind the pond tanks) are an excellent choice for use with a pond or well water source. A large portion of the sides and back of the tank is buried. A winter flow valve continuously releases a small amount of water into the drinking area to assure continual inflow of warmer underground water. Installation can be in any location where the back and sides of the waterer can be buried.

Ground Source Heat

Installing earth heat tubes that extend into the soil 4 feet or more below the waterer and around the incoming water line can be used to increase effectiveness of all tanks.

Flow through systems are used with open-topped tanks. As with the behind-the-pond tanks, warm water in the tank is replenished through the use of a release valve and discharge system. Typically a greater amount of water is used on open-topped tanks due to the greater surface that is exposed to the cold conditions. Flow through system designs vary widely but all are designed to bring warmer water into the tank and overflow it through a drain from the tank. The amount of water to be discharged depends on the air temperature and the temperature of the water entering the tank.

The location of the released water varies from the bottom of the tank to the surface of the tank. In all cases it is designed to prevent the valve and float compartment from freezing, but allowing the remainder of the surface water to freeze. An ax or other tool may be needed to break the ice on the surface.

Overflow pipes can allow water to continuously trickle out of tanks, with comparatively warm groundwater water (50 to 60 degrees Fahrenheit) constantly refilling the tank. Overflow pipes can be used with open-topped tanks and in conjunction with spring developments, but the water supply may be depleted during dry weather and droughts. Overflow water needs to be diverted away from the tank to avoid mud hole formation.

Some systems use a temperature-sensitive system to control the amount of water released, while others have a manually-operated valve or need periodic pumping to reduce or prevent freezing.

Some companies offer Ice preventer valves which have a gas-filled coil or chamber that expands as the temperature drops. Near the freezing point, the valve opens and water flows into the tank. The coil may fail sooner than the rest of the waterer but can be replaced with either a gas or mechanical valve unit. A common brand name for ice preventer valve is Walters.

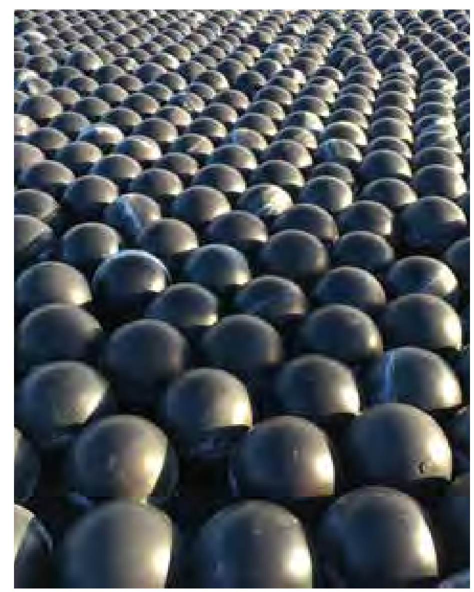
Many manually adjusted flow valves are not compatible with high pressure incoming water systems, as high pressure flow will cut into the brass parts of the valve. Watson bleeder valves are commonly used with gravity-flow systems. In some cases the bleeder valve is used in conjunction with tubing that directs the flow of water onto the stream, which increases effectiveness. The more horizontal the flow onto the water surface, the greater the freeze protection.

Bulls-Eye hose nozzles are used with higher pressure water systems and constrict the flow of water into a straight thin stream up to ¼-inch wide stream, providing high pressure with good velocity compared to other nozzles. The nozzle has garden hose threads, is leak-proof and shuts off completely to avoid drips.

Tank heaters used with open-topped tanks conserve water, as flow is not used to warm the water. The heater is dropped in the tank and is most commonly powered by electricity. An automatic control turns on the heater as the water temperature drops below 40 degrees Fahrenheit. Heaters using propane, wood, coal, or other fuels can be used in remote locations but require more labor and may be more costly to operate. Installing a lid on top of the tank with a small cutout for livestock access to water can reduce heating costs for all open-top tanks. Heater elements will require periodic replacement.

Surface agitation with pond mills and aeration can reduce ice formation on ponds. Aeration is accomplished with compressed gas released through tubing into a porous air stone, where the gas diffuses into the water as small bubbles. Aeration systems can also be powered by solar panels that run small air pumps, with a deep cycle battery as nighttime backup. The depth of the water where the air stone is placed will affect how much of the pond surface will be affected. Shallow placement may only keep 3to 12 inches of the surface ice-free, while a deeper placement will impact a larger area, as the water moved by the air is warmer at deeper depths and is less focused. Pond mills are driven by the wind and are often used for summer aeration. Their effectiveness in ice prevention is reduced on cold, still nights.

Shade balls are primarily used to reduced water evaporation, but may provide some freeze protection due to their dark color absorbing heat and the movement of the balls on the water. Shade balls could become a liability if the water in the tank freezes and breaking the ice becomes necessary.



Other Issues: Maintenance and Management

Combining Watering System Components

Livestock watering systems can be as simple as a stream or pond within a pasture where livestock have direct access to water. An improved watering system may minimize livestock impacts on water quality and reap economic and health benefits.

Each watering system will have several components:

A **tank** or other drinking device. The size and type of the drinking device is dependent upon the species and number of animals to be watered and the water refill rate.

A delivery **pipeline**. The pipe size, construction material, and thickness can differ depending on the number of livestock to be watered and the length of time livestock are in the pasture. Temporary watering sites may utilize smaller and or lighter gauge materials.

The **water source** is important in designing a watering system. If the water comes from a pressurized public water source such as a rural water pipeline, most likely an on-site pump will not be necessary. However, it's necessary to check both the flow rate and pressure at the tank; low pressure will limit the flow rate, while high pressure can cause leakage problems with water valves and require a change of valve style. If the water source is from a slowly flowing spring, a pump may be needed to move the water to a higher elevation and/or a storage tank. While many ponds are constructed with livestock watering in mind, many do not have enough elevation drop below the pond to accommodate a gravity-flow system.

Pumps and gravity-flow systems both use energy. Pumps typically use external energy sources such as electricity, while gravity flow is powered by the kinetic energy of the water pressure created by the desired 6 ft elevation fall from the pond surface to a water tank situated below the dam.

Pump selection is dependent on the specifics of each site such as the elevation difference between the water source and the drink delivery device, the depth of the well, and volume, speed and distance the water will be moved.


SHARON

Permits in Kansas

Producers can avoid delays associated with lengthy processing procedures, investigations, or possible litigation by following requirements related to building, removing, or altering federal and state waters (including wetlands). Following regulations reduces the potential for a registered public complaint or civil lawsuit, saves taxpayer dollars, and protects the beneficial use of state waters for yourself and your neighbors.

Secure all permits prior to beginning construction to avoid costly delays, rework or additional permit fees. Begin the permit application process well in advance of your anticipated construction start date, as a minimum a 30-day comment period is required for notification of interested and concerned agencies and organizations. Total permit processing time can stretch to several months.

Water development permits are issued by several agencies in Kansas, and a single development project may require multiple permits from more than one agency. Contact the agencies below for permit information that may be pertinent to your project. Note that this is not an exhaustive list, and that rules and regulations are subject to change.

Kansas Department of Agriculture, Division of Water Resources (KDA)

The water structures program regulates manmade structures that impact streams to ensure they are properly planned, constructed, operated, and maintained to avoid adversely affecting the environment, public health and welfare, and public and private property.

Examples of activities that are regulated by the water structures program include: grassed waterways, construction, modification, or repair of dams; bridges, culverts, weirs, low-water crossings, low-head dams, intake and outfall structures; boat ramps, pipelines and cable crossings, levees along streams, placement of fill within the floodplain, and gravel or sand dredging.

A permit is required from KDA for construction, modification or repair of a dam that is 25 feet or more in height, or 6 feet or more in height with the ability to store 50 acre-feet or more of water at the auxiliary spillway crest.

Smaller dams may still require a permit if KDA's chief engineer determines that the watercourse where the dam is located is an obstruction of a stream channel.

Ask KDA for a determination on your planned project to confirm if a permit is needed.

Appropriating water for livestock's use may also require a permit. Water for livestock in a pasture or in a confinement feedlot of less than 1,000 animals is considered domestic water use and a permit is not required.

Larger concentrated livestock operations (feedlot of more than 1,000 animals or dairy operations using more than 15 acre-feet of water annually) require a water appropriation permit.

(785) 564-6640
http://www.agriculture.ks.gov

U.S. Army Corps of Engineers

The Corps of Engineers requires that permits be obtained to meet requirements of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act.

Section 404 regulates discharge of dredged or fill material in all waters of the United States including rivers, streams, lakes, and wetlands. This includes dams and dikes, bank stabilization (riprap, seawalls and breakwaters) levees, mechanized clearing of wetlands, pipeline and cable crossings, grassed waterways, other channel modifications, and other activities. Contact the Corps to determine if your project requires a 404 permit.

Work in, on, over, and under a navigable body of water also requires a Section 10 Rivers and Harbors Act permit. Examples are bridge construction, channel straightening, and wetland draining. Contact the Corps to determine if your project impacts navigable water.

http://www.nwk.usace.army.mil/missions/regulatory-branch/

(816) 389-3990 (Kansas City District)

https://www.usace.army.mil/missions/civil-works/Regulatory-Program-and-permits/Obtain-a-Permit/

Kansas Department of Health and Environment (KDHE)

Prior to obtaining a Corps of Engineers 404 permit, a Section 401 Water Quality Certification must be obtained from KDHE to verify that the project is following state water quality standards. The certification must be issued by the state before the corps will issue its permit.

A certification application is automatically filed when a Section 404 permit is requested. The KDHE will evaluate the project and approve the action, approve it with modifications, or deny the action based on projected water quality impacts.

The KDHE also requires a water quality protection plan to ensure that water quality is not impaired during construction. This must be posted at the construction site during construction.

Water for confined livestock operations requires additional permits. Contact the Kansas Department of Health and Environment to discuss your proposed plans and determine specific requirements.

https://www.kdhe.ks.gov/documentcenter/view/9933

http://www.kdhe.ks.gov/

(785) 296-5545

Local Code Regulation and Permits

Many municipalities, counties, and watershed protection areas require permitting and reporting of water developments. Check with the local county health department, environmental resources department, or code enforcement office to determine what regulations pertain to your site.

Kansas 811

Excavation activities that sever optic fiber or other utility lines can result in very expensive repair charges. Call Kansas 811 prior to beginning any excavation work to have underground utility infrastructure marked on site so it can be avoided.

http://www.kansas811.com/

811 or (800) 344-7233

Plugging Abandoned Wells

A source of clean, safe household water is important to all Kansans. Groundwater is often the only source, especially in areas with no public water supply. Groundwater is usually preferred for individual homes because it does not require filtering.

Groundwater use does require wells, and wells act as conduits for possible entrance of contaminants. Many test holes and unused (abandoned) wells are located in fields, farmsteads, industrial sites, and urban areas without being properly plugged. Not only are wells sources for potential contamination of groundwater, many are a physical hazard to animals and people, particularly children (see photo).

Landowners are liable for contamination or injury from unplugged wells or holes. The hazards of abandoned wells and test holes should concern everyone. They should be properly eliminated. This bulletin is provided to help landowners, service providers, and others understand the correct plugging procedure.

The Kansas Department of Health and Environment (KDHE) estimates more than 250,000 abandoned wells and test holes exist in Kansas. Kansas law defines an abandoned well as one that

- has not been used during the last 2 years;
- is in such disrepair that it cannot be used; or
- poses a groundwater-contamination hazard.

Kansas law requires that all abandoned wells and test holes be properly plugged. Proper plugging accomplishes five goals:

- restores protective barrier to minimize groundwater contamination;
- removes physical hazards by removing tempting openings for curious children and animals;
- restores stability to the land surface (load carrying capacity);
- eliminates or reduces liability exposure; and
- protects and improves property values.

Kansas Regulations

The Kansas Department of Health and Environment administers laws regulating construction, reconstruction, and plugging of wells. Articles 12-K.S.A.82a-1212 and 1213 and 30-K.A.R. 28-30-4(a) and 28-30-7 specifically address plugging of abandoned wells. The regulations provide instructions for all types of wells and aquifer conditions. Well drillers and landowners alike are required by law to follow these procedures, which are available from KDHE.

This publication describes the easiest plugging procedure for the most-common well and aquifer conditions. If well or aquifer conditions are unknown or different from those described, landowners should contact KDHE for the proper plugging procedures. Landowners may plug wells on their property by following these procedures. Landowners also can hire a licensed water well contractor to plug a well.

The plugging procedure requires a plugging report (form WWC-5 or form WWC-5P) be filed with KDHE. These forms can be obtained by calling (785) 296-5524 and are frequently available locally through county health or local K-State Research and Extension offices. Failure to file this report documenting proper closure leaves the owner liable for contamination. Documentation of the plugging procedure transfers the burden of proof to the complainant.

Aquifer Classification

Often for older wells, little specific information is available about the well or the aquifer source. The type of aquifer or water formations penetrated by the well must be known for proper plugging. Sometimes this information can be obtained by asking questions of knowledgeable sources. Well logs for the actual well or nearby wells may be available from local drillers or KDHE. Geological and groundwater reports are available for most counties. Check the library or call the Kansas Geological Survey at (785) 864-3965.

Something must be know about the soil and geology (sand, gravel, clay, rock) of the well to ensure plugging will restore the integrity of the formation. Aquifers, the permeable water-bearing materials supplying a well, are classified based on the geology of the formation.

When water from the surface moves directly into an aquifer, it is called unconfined. Confined aquifers, in contrast, have impervious layers that significantly restrict direct local recharge from the surface. Water in confined aquifers may be under pressure greater than atmospheric, and water rises above the restricting layer (artesian).

When the water-bearing layer is made up of individual grains of sand and gravel, the aquifer is called unconsolidated. All other aquifers are considered to be consolidated aquifers, often referred to as rock aquifers. Thus, there are four types of aquifers: unconfined-unconsolidated, unconfined-consolidated, confined-unconsolidated, and confined-consolidated.

Many aquifers are more complex than this simplified explanation. A consolidated formation may have several water-bearing zones separated by confining layers of varying permeability. Each zone may have a

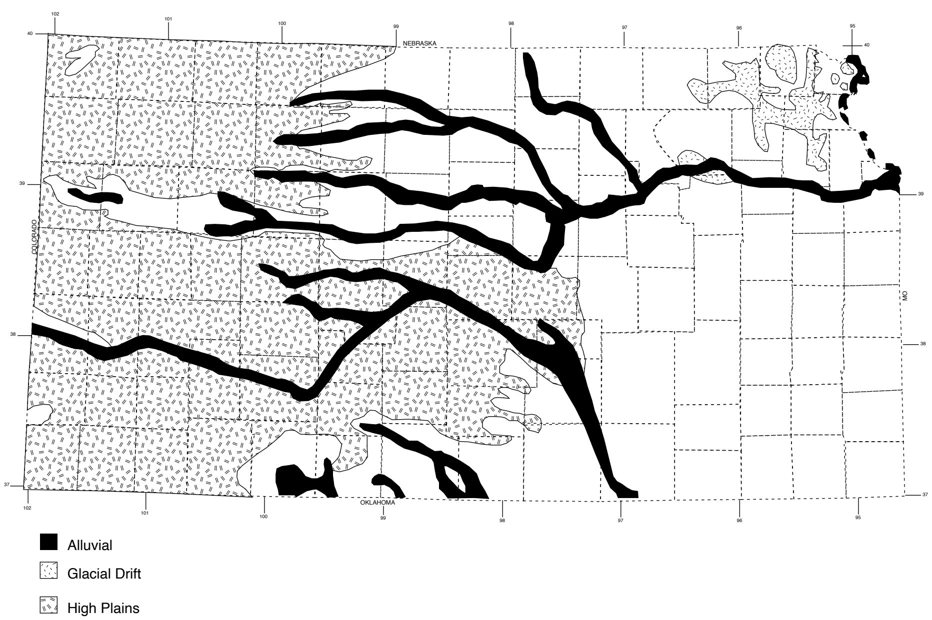


Figure 4. *Sand and gravel aquifers.*

different yield and water quality. Good-quality water may lie above, below, or between zones of poor-quality water. Experienced well drillers recognize and note these differences as the well is drilled and connect or exclude various zones, based on the quality and quantity of water needed.

The procedure described here applies when plugging wells located in unconfined aquifers with unconsolidated formations. If a formation is suspected to be rock, (consolidated formation), has confining layers, or the well penetrates multiple water-bearing formations, contact KDHE before proceeding or hire a licensed well driller to do the plugging. Do not attempt to use these procedures to plug wells in conditions other than unconfined and unconsolidated.

The procedure described generally applies to the sand and gravel aquifers shown in Figure 4. Other areas may not be sand and gravel aquifers. Generally, shallow wells (less than 50 feet near streams, and 100 feet on uplands), can be plugged with this procedure. Large-diameter (12 inches or more) irrigation, industrial, or municipal wells also might be best handled by a licensed well driller.

Well Classification

Wells are classified according to their construction. Understanding well construction methods is important because different types of wells require different plugging procedures. The oldest type is the dug well. These are large diameter, relatively shallow, hand-dug wells, usually lined with rock or brick. Typical dug wells are 3 to 6 feet in diameter and 15 to 50 feet deep (see Figure 5). The depth depends on depth to water, and size can vary from 2 feet in diameter to larger than 30 feet.

A driven well, used mainly for shallow, unconsolidated aquifers, is named for the process of driving the suction pipe with screened section into the sandy water-bearing formation. These wells are generally small in diameter with pipe sizes of 1 to 2 inches for home water supplies and up to 6 inches for irrigation and livestock wells. Driven wells are limited to sandy formations with high water tables, where centrifugal or shallow well jet pumps can be used. Driven or sandpoint wells are still being installed. To be legal, however, they must be grouted to a depth of 20 feet

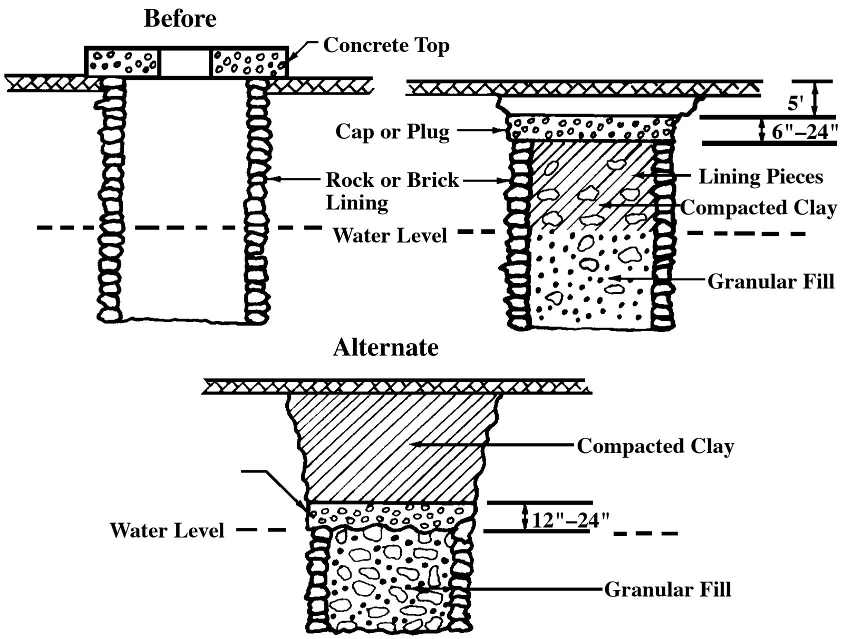


Figure 5. *Plugging diagrams for a hand-dug well.*

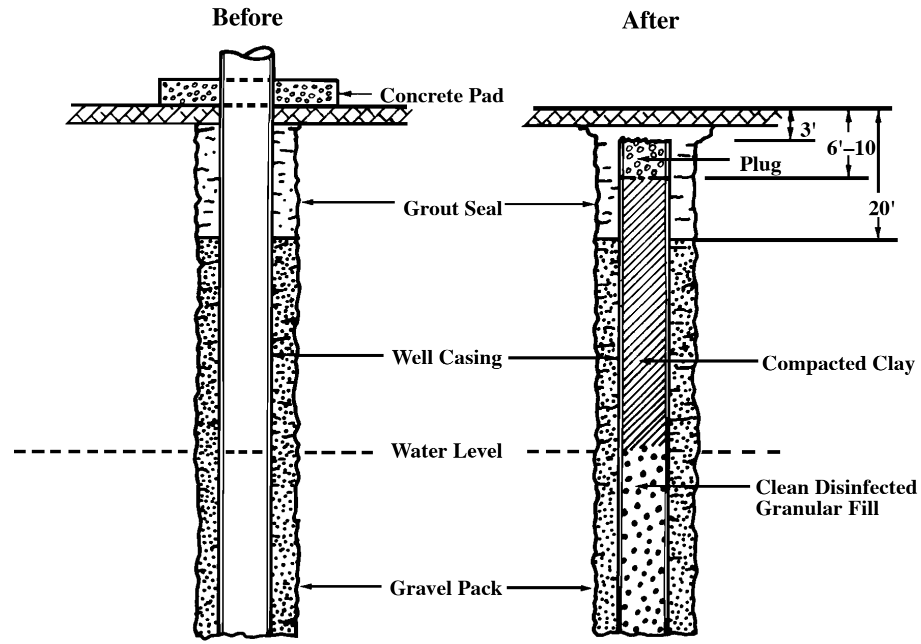


Figure 6. *Plugging diagram for a drilled well in an unconfined (unconsolidated) aquifer.*

or to the water table. Because of shallow depths and grouting difficulties, driven wells are discouraged for domestic use.

The drilled well is the most common type of well in Kansas (see Figure 6). Typically, a hole is drilled into the aquifer, and a casing 3 to 8 inches smaller than the bore hole is installed. Domestic and livestock watering wells are generally 4 to 10 inches in diameter, while irrigation wells generally range from 10 to 18 inches.

The depth of a drilled well varies depending on the aquifer and water depth. Depths greater than 300 feet are common in some places. The small-diameter well casings, usually 6 inches or less, are generally installed in bore holes only a few inches larger than the casing. Typically, the casing is inserted after the bore hole is drilled.

For large-capacity wells for irrigation, industrial, or municipal uses, the casing is installed into oversized holes. The space between the casing and bore hole is filled with gravel. This gravel pack allows unrestricted water flow into the perforated portion of the casing and acts as a filter to retain the aquifer particles. Near the surface, this space is filled with grout to prevent water movement from the surface along the casing.

Before 1975, grouting was not required and the common practice was to pack gravel to very near the surface to induce the greatest yield possible. This practice made flow along the outside of the casing an easy pathway for contaminants to enter the groundwater from the surface.

Plugging Procedure

The plugging procedure described is for wells in an unconfined-unconsolidated aquifer (Figures 5, 6, and 7). If the well has more than one water-bearing layer, penetrates a confining layer (aquiclude), or goes into rock, contact KDHE to make certain of the proper plugging procedure or hire a licensed well driller. Plug wells using these steps:

Step 1. Prepare site. Remove all pumping equipment and any foreign objects from the well and remove debris from the surface around the well site.

Step 2. Remove top of casing. Excavate around the casing of a drilled or driven well to a depth that allows the casing to be cut off at least 3 feet below the surface. The more casing removed, the better.

When excavating around the old casing, look for evidence that the well was properly grouted (Figure 6). Establishing a proper seal is critical to preventing contaminants from migrating along the outside of the casing. When a well does not have a proper grout seal, it should be restored. This requires 20 feet of excavation around the outside of the casing to allow placement of the grout. However, if it is possible to excavate this deep, the casing should be removed to this depth rather than be grouted.

Since deep excavation of a nongrouted well is often not practical, another option is to extend the plug beyond the edges of the original bore hole at least 1 foot outside the casing in all directions. This mushroom plug, shown in Figure 7, will help prevent water movement along the outside of the casing. Deeper excavation than the 3-foot minimum around the casing is especially desirable when no grouting exists outside the casing.

In dug wells, the casing of the well is the rock or brick lining of the well. This lining can be used as part of the fill material. The lining for dug wells should be removed to a depth of at least 5 feet. Be certain to mix lining material with fill material (see steps 4 and 5).

Step 3. Disinfect water. Existing bacteria or bacteria carried to the water by the fill material should be killed. This helps prevent contamination of nearby wells. Determine the amount of chlorine necessary by measuring the depth of water and diameter of the well and estimating the amount of water in the well. Then use Table 12, which lists the amount of chlorine product to add to produce a solution concentration in the well of approximately 500 milligrams per liter of chlorine.

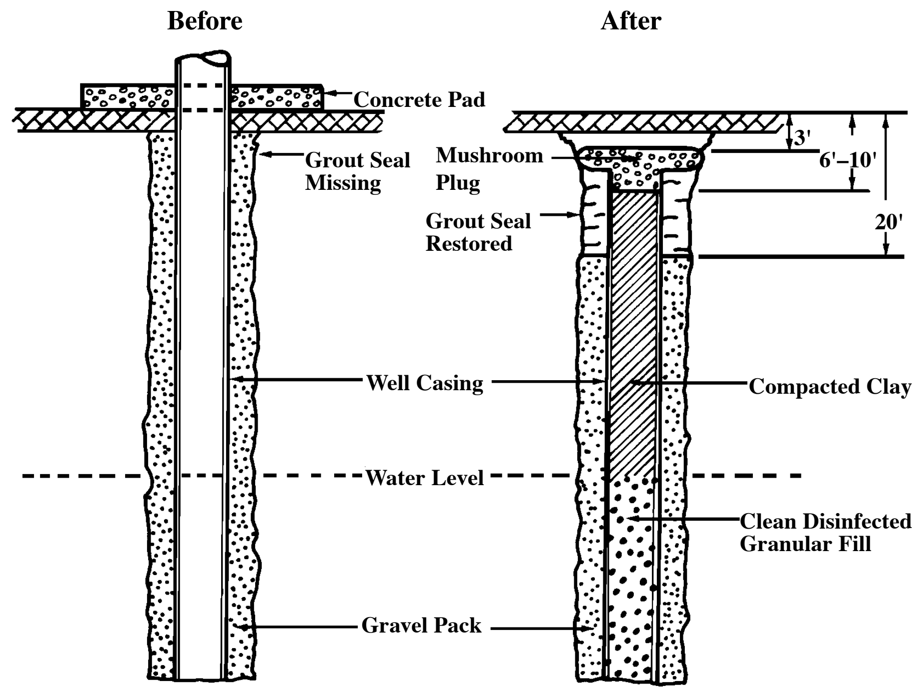


Figure 7. *Plugging diagram for a drilled well without proper grouting in an unconfined-unconsolidated aquifer.*

The amount of chlorine needed depends on the product concentration. Four concentrations representing various chlorine products from household bleach (5.25 percent) to dry chlorine disinfectant (70 percent) are shown in Table 12. When dry chlorine is used, dissolve it in water before adding it to the well to make certain the material does not settle to the bottom.

If no working wells are within 100 feet of the abandoned well being plugged, the concentration of chlorine could be halved since bacteria migration beyond 100 feet is unlikely.

Table 12. *Computing volume of fill material and disinfectant for wells.*

Diameter of Opening	Volume of Well per Foot		Amount of Product to Disinfect 1 foot (a)			
			Liquid Chlorine (fluid ounces)		Dry Chlorine (dry ounces)	
	gal/ft	ft^3/ft (b)	5.25%	10%	65%	70%
2 inches	0.16	0.02	0.20	0.10	0.02	0.02
3 inches	0.37	0.05	0.45	0.22	0.05	0.02
4 inches	0.65	0.09	0.80	0.42	0.07	0.07
5 inches	1.02	0.14	1.25	0.65	0.10	0.10
6 inches	1.47	0.20	1.80	0.95	0.15	0.15
8 inches	2.61	0.35	3.20	1.67	0.27	0.25
10 inches	4.08	0.55	5.00	2.60	0.42	0.40
12 inches	5.88	0.79	7.20	3.75	0.60	0.55
14 inches	8.00	1.07	9.77	5.12	0.82	0.77
16 inches	10.44	1.40	12.77	6.67	1.07	1.00
1.5 feet	13.22	1.77	16.17	8.45	1.35	1.25
2.0 feet	23.50	3.14	28.75	15.05	2.42	2.25
2.5 feet	36.72	4.91	44.92	23.50	3.77	3.50
3.0 feet	52.88	7.07	64.70	33.85	5.42	5.05
4.0 feet	94.00	12.57	115.02	60.15	9.65	8.97
5.0 feet	146.9	19.64	179.75	94.00	15.07	14.00
6.0 feet	211.5	28.27	258.75	135.37	21.72	20.17
7.0 feet	287.9	38.48	352.25	184.25	29.55	27.45
8.0 feet	376.0	50.27	460.25	240.65	38.60	35.85
9.0 feet	475.9	63.62	582.25	304.50	48.87	45.37
10.0 feet	587.5	78.54	719.00	376.00	105.32	56.02

(a) 500 mg/L concentration of chlorine; 128 oz. = 1 gallon
(b) 27 ft^3 = 1 cubic yard

Example: A 6-inch diameter well, 60 feet deep, has 20 feet of water present. How much chlorine is needed for disinfection?

At the intersection of the 6-inch and 5.25-percent column in Table 12, 1.8 fluid ounces of bleach is needed for each foot of water, so 36 ounces, or 2.25 pints, (1.8 × 20 ounces) of bleach should be added.

Step 4. Fill water zone with clean porous material. Approved fill material is sand and gravel of less than 1-inch diameter. Generally the preferred fill is washed, coarse river sand. The fill material is chlorinated when it is added to the previously disinfected water in step 3. Table 12 also shows the volume of fill needed per foot of well for various diameter holes. The water in the well may rise as the sand is added, depending on the permeability of the formation and the fill material. Estimate the volume of fill needed to avoid filling above the normal water level. Measure the normal water level using a weighted string that just touches the water surface. Mark the string with a knot at the top of the casing. Begin adding fill, but periodically check progress of the fill. Once the weight touches the top of the fill at the marked spot, stop adding fill. Even though the water level may have risen, add fill only to the original water level. Any water above the normal water level should be removed by pumping or allowed to soak away with time. The use of coarse sand and slow addition to the well will prevent bridging of the sand at the water surface. The sound of the sand hitting the water surface should be heard.

In dug wells, more fill than recommended from the table generally is required to fill this zone because mud in the bottom of the well compresses and moves into voids in the rock lining. It may be necessary to bring as much as 30% more fill than predicted from the table.

Although the lining rocks can be added in either the sand or subsoil layers, it is preferable to add rocks with the subsoil as discussed later. This will keep the water-bearing area much cleaner, as it is difficult to remove the rock lining without a lot of debris from the surface falling into the well.

In some wells, especially those less than 20 feet deep, there may not be enough volume to dispose of the rocks in the subsoil layer only. In this case, some of the rock lining should be placed in the fill. Generally, the rock or brick lining can be pried loose with large pry bars. However, a backhoe or front-end loader may be desirable for large-diameter wells. When using heavy equipment, the surface soil around the well site should be scraped away to expose the subsoil layer. As the rock walls are added, be certain to add sufficient fill material to eliminate any voids among the rocks.

Example: For the 6-inch diameter well with 20 feet of water, how much sand is required?

From Table 12, at the intersection of 6-inch diameter and the column from the left side, 0.20 cubic foot of fill is needed for each foot of the 20-foot water zone, therefore, 4 cubic feet ($0.20\ ft^3/ft \times 20\ ft$) of fill is needed. Since there are 27 cubic feet per cubic yard, 4 cubic feet equals 0.15 cubic yard.

Step 5. Add compacted subsoil above the water zone. The casing above the water level is filled with natural subsoil clay material (subsoils low in organic matter and other potential contaminants) and compacted to form a solid column. The subsoil should be placed in a dry hole. The subsoil should be damp to allow it to compact easily. The clay fill should be placed in layers not exceeding 2 feet.

For small-diameter wells, a section of steel pipe with a cap on one end attached to a rope makes a good tamping tool. The fill should stop at least 3 feet below the top of the casing (6 feet below the surface) to leave adequate space for an approved plug.

Dug wells are filled to no more than 5 feet below the surface. At this point, the rock lining and subsoil fill should be leveled off.

Step 6. Place an approved grout plug. Pour the approved grout material into the drilled or driven well casing, making a plug at least 3 feet thick, the minimum required. In a dug well, the plug of approved grout material is 6 to 24 inches thick. Grout material approved by KDHE includes commercial hole plug sodium bentonite clay, cement, and neat cement. Cement grout is a mixture of equal volumes of portland cement and sand. Use 10 to 12 gallons of water for each bag of cement. Neat cement is a mixture of portland cement and water, and 5 to 6 gallons of water should be used for each 94-pound bag of cement.

Table 13. *Number of bags of sodium bentonite clay needed for various well diameters.*

Diameter of Opening (inches)	Feet of Fill per Bag (a)	Bags (a) per Foot	Bags (b) per 3-Foot Plug
2	35.0	0.03	0.1
3	14.0	0.07	0.2
4	7.8	0.13	0.4
5	5.0	0.20	0.6
6	3.5	0.29	0.9
8	2.0	0.50	1.5
10	1.3	0.79	2.4
12	0.9	1.13	3.4
14	0.7	1.53	4.6
16	0.5	2.0	6.0
18	0.4	2.5	7.5

(a) Table values based on 50-pound bags, which have a volume of $0.7\ ft^3$ per bag.
(b) Additional bags are required for mushroom plugs extending outside the casing (see step 6).

Sodium bentonite clay, normally sold in 50-pound bags that contain 0.7 cubic foot, is recommended for use because it is easy to handle, remains pliable, and expands when in contact with water. Because of bentonite's expansive and pliable nature, it will conform to the uneven rock edges and expand to fill voids in the wall. If any settlement should occur, the bentonite seal will not crack or lose its integrity.

Table 13 provides information to help determine the number of bags of sodium bentonite clay needed for placing the plug or filling the entire well with bentonite. A cement plug must be much thicker and may need reinforcement to have enough strength to prevent cracking and collapse.

Example: A 6-inch diameter well is ready for the plug material. How many bags of bentonite are needed?

From Table 13, a 6-inch diameter well has a volume of 0.2 cubic feet per foot of casing. A typical bag of bentonite contains 0.7 cubic feet of material. Dividing 0.7 cubic feet per bag by 0.2 cubic feet equals 3.5 feet of casing per bag. Therefore, one bag will make a 3.5-foot plug inside the well casing. Several more bags will be needed to make the mushroom plug on top to protect the outside of the casing (see step 2).

Example: A 4-foot diameter well is ready for the plug material. How many bags of bentonite are needed?

Since bentonite is expansive, the minimum 6-inch plug will be used. Remember, the plug should extend beyond the rock lining to the original hole diameter. For this example, assume the rock lining is 1 foot thick; therefore a 6-foot diameter plug must be placed.

From Table 12, a 6-foot diameter hole requires 28.27 cubic feet of material. Since only a 6-inch plug is required, only 14.14 cubic feet of material is needed. Dividing 14.14 cubic feet by 0.7 cubic foot per bag determines that 20.2 bags (round up to 21 bags) are needed.

Step 7. Fill hole at top. Once the grout plug and mushroom cap have been completed, the remaining hole above the plug should be filled. Subsoil material can be placed in the bottom of the hole and compacted as the fill progresses in layers of 6 inches. Topsoil should be used in approximately the top foot of the hole. The fill should be mounded up at least 10 inches in the center to allow for settling and drainage away from the fill site.

Step 8. File the plugging report. Abandoned wells are an environmental and safety hazard. They are a liability. Follow the plugging procedure described here and file form WWC-5P or WWC-5 with KDHE to document the action minimize further liability.

The well is not legally plugged until the form is filed. The WWC-5 form is used by drillers for reporting a new well. It asks for location, property owner, physical characteristics of formation, well, casing, and the plugging procedure used. A new WWC-5P form was developed specifically for reporting well plugging. Forms are available from KDHE, but many county Extension, county health, and conservation district offices also have these forms available.

Alternative Plugging Option

For small-diameter wells, especially shallow ones, it is simpler to plug the entire casing with approved grout material or with sand fill below water and grout above water. This is a good choice for very-small-diameter wells where placement of the various layers of fill, especially the subsoil fill, may be difficult. Filling the entire casing with grout may be the best option for small-diameter driven wells. A 2-inch diameter well needs only 0.02 cubic foot of fill per foot of casing. This means one bag of bentonite will fill 35 feet of well. The well water still needs to be chlorinated.

Sodium bentonite clay chips or pellets can easily be used to completely fill the casing. Bentonite clay powder or granular material should never be poured into wells with water. Proper placement of powder or granular materials requires making a slurry and using a grout pump.

Placing cement grout into water. If cement or neat cement is used as grout, placement into water requires special procedures to avoid separation. A tremie pipe, which is usually about 3 inches in diameter and in sections 5 to 10 feet long, will be needed to place the cement without passing through water. Use enough pipe to reach within a foot or two of the bottom and cut the end at a 45-degree angle. A hopper box or large funnel is attached to the top of the tremie pipe. The grout is mixed and placed in the hopper or funnel.

The mix must be thin enough to flow, but thick enough to set properly once in place. The proper ratio for neat cement grout is one 94-pound bag of cement to 5 or 6 gallons of water. For cement, use 5 or 6 gallons of water for each cubic foot of cement-sand mix. The volume of material must be monitored during placement because the tremie pipe is raised as the fill progresses. The end of the tremie must be kept below the surface of the grout at all times to prevent dilution and separation of the grout mix.

Precaution: Remember how much material is in the tremie pipe at all stages and approximately how much depth it will fill. A 10-foot section of 3-inch diameter tremie contains nearly a half a cubic foot, so 100 feet would contain 5 cubic feet. If filling an 8-inch casing, which contains 0.35 cubic feet per foot of length, ignoring the volume in the tremie would be an error of 14.3 feet. Tag or measure the progress of the plugging material as the well is filled, and pump or siphon off any excess water that is displaced as the grout is added.

Plugging Confined, Multiple-zone or Rock Aquifers

If the aquifer is known to contain confining layers or more than one water-bearing zone, a plug at each confining layer between each aquifer is required. If the outside of the casing was not grouted at those locations, as was common with old wells, the casing should be ripped and grout pumped into the gravel pack to restore a good seal at the confining layer. Most licensed well drillers have equipment to rip or puncture casing so grout can be forced into the gravel pack. Landowners are advised to hire a competent licensed water well driller to plug all confined, multiple-zone or rock aquifers and other unusual formations. In addition to having needed equipment, a driller should know the local geology, so grout plugs and other materials are placed correctly.

Oil and Gas Wells

Plugging abandoned oil, gas, or brine-disposal wells is equally important. Report these wells to the Kansas Corporation Commission to be sure they are properly plugged. The KCC's district offices are in Dodge City, (316) 225- 8888; Wichita, (316) 337-6231; Chanute, (316) 431-6946; and Hays, (785) 628-1200.

Conclusion

Abandoned wells are potential sources of direct contamination of valuable groundwater. Wells larger than a few inches in diameter also are a safety hazard for children and animals. All abandoned wells should be properly plugged to prevent contamination and eliminate the safety hazard. Plugging is required by Kansas law. When a replacement well is drilled, the old well, according to law, must continue to be used, upgraded to current standards, or plugged. It is not uncommon to visit a farmstead and find three or four wells with only one or perhaps two currently in use. While there is a reluctance to pay to get rid of something that has outlived its usefulness, groundwater protection, safety, and Kansas law make plugging important. Abandoned water wells can no longer be ignored.

Shade Balls

Overview

Shade balls are numerous black plastic balls that float atop the water in a livestock watering tank. The balls cover about 90% of the water surface in the tank and can be pushed aside by livestock when they drink. Shade balls assist in maintaining water temperature in a comfortable zone for livestock.

Advantages

- Reduces water temperature in the tank during the summer by about 9 degrees.
- Acts as water insulators in the winter, increasing water temperature by about 9 degrees.
- Reduces ice formation in the tank.
- Excludes birds from using the tank, reducing incidences of coccidiosis in livestock.
- Reduces the amount of sunlight reaching the water and decreases algae growth in the tank.
- Substantially reduces evaporation from the tank, conserving water.
- Reduces the amount of debris falling in the tank, reducing maintenance.

Limitations

- Costs about $2,000 to cover a 20-foot diameter-tank.
- Difficult to find a source.
- May not be eligible for cost-share.

Design Considerations

Shade balls are constructed of ultraviolet-stable (UV) high-density polyethylene (HPDE). A typical size is a 4 inch diameter ball. The balls readily rotate, discouraging birds from perching. The thick-walled balls are partially filled with water during manufacturing so they will sit low in the water to avoid being lifted out of the tank by the wind. Tumbleweeds blow across the tank rather than sinking and filling the tank with debris.

https://www.farmshow.com/a_article.php?aid=35247

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Stalcup, Larry. (2019, May 7). *How shadeballs can help your cow tank*. Beef Magazine. *https://www.beefmagazine.com/water/how-shadeballs-can-help-your-cow-tank*

Waterer Valve Maintenance and Repair

An ounce of prevention is worth a pound of cure when it comes to livestock waterer maintenance. Waterer maintenance is not generally difficult, but it does take a little time. Keeping the waterer clean is a primary maintenance activity. Cleaning may need to occur as often as once a week or as rarely as once a year, depending on the type of waterer, water quality, and livestock diet. Waterers supplied by pond water will need to be cleaned more frequently than those supplied by public water or well sources.

The waterer level control valve should be checked frequently, often monthly, for proper fit around pipe threads and for wear of the plunger and the seat. As the seal begins to fail, the water level will begin rising and eventually cause the waterer to overflow. Most water level control valves in automatic waterers are designed with plunger rubbers or diaphragms that are easy to replace. Water level control valves that seep due to rubber plunger seat wear are wasteful, a nuisance, and make a mess around the waterer site. In most cases the solution is to replace the rubber plunger, diaphragm, or "O" ring.

Waters with chronic valve problems may need further investigations. The rubber plunger seats should last a year or longer. In some cases, as a result of high pressure, the float for the valve is nearly submerged when the water level should be shutting off the water (the float should be only ½ to ⅔ submerged). The solution may be to add additional length to the float rod or change the valve to a high-pressure valve that is designed to shut off with water line pressures of greater than 60 psi. In Franklin- or Miraco-style valves, replacing the orifice with a smaller higher-pressure orifice may solve the leaking issue.

Before beginning maintenance, turn off the water pressure to the waterer. Remove any covers so the valve is easily accessed. Maintain the tightness of the connection between the float rod and the valve lever which adjusts the water level in the tank. Maintaining the float level setting may be possible by removing the hinge pin on the valve body and setting aside the entire float rod assembly.

Franklin-type valves. Remove the plunger for inspection. If wear or damage is minimal, reverse the plunger rubber and reinstall; otherwise install a new plunger rubber. Reassemble the valve components and turn the water back on. Monitor the waterer valve operation and water level as it refills. If the float rod was loosened, wait until the float shuts off automatically to make sure it is adjusted correctly before replacing the valve cover.

Pride of the Farm valves. Unscrew the large ring to disassemble the valve. Generally these valves will not display indications of failure until failing all at once due to a small hole in the diaphragm. When replacing the diaphragm, special care should be taken not to lose the small O-ring on the plunger. Check the numerous small plastic parts for alignment when reassembling.

Watson valves do an excellent job with gravity-flow water pressures. Do not use these valves when water pressure exceeds 80 psi unless a pressure reducer is installed that reduces water pressure to near 50 psi. Adding additional float material to force the valve to seal under high pressure conditions can cause the water to cut into the brass valve seat.

Hudson, Jobe, and Apex water level control valves are diaphragm valves, suitable for use with higher pressure systems. These valves are relatively maintenance-free, except occasionally fine sediment gets caught in the valve filter or the tiny passageways get plugged when using water that contains sediment. After the passageways are plugged, the valve will remain in the open position until it is cleaned out. The passageways are easily cleaned using a fine wire, such as the wire tie from a bread wrapper.