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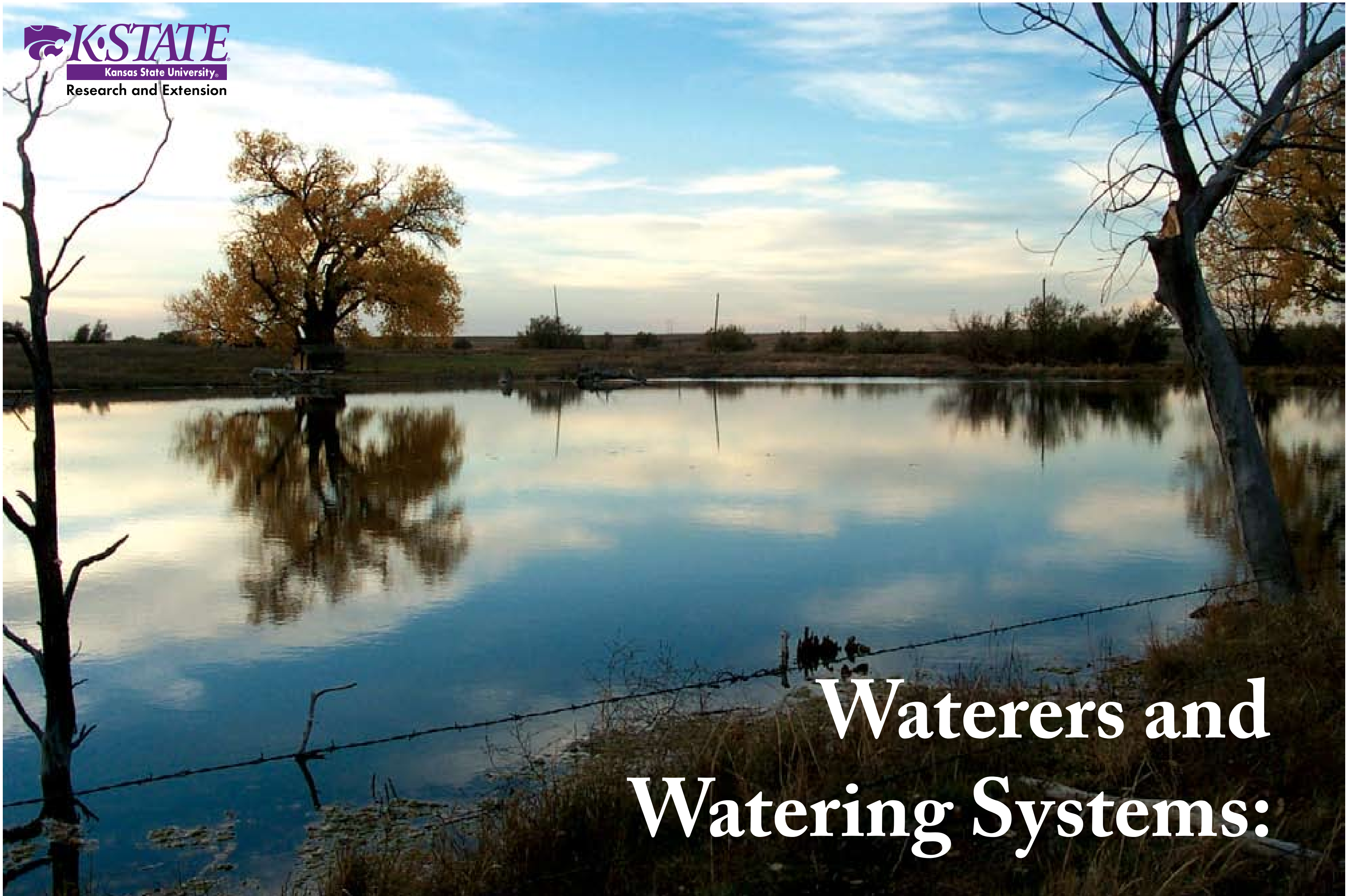

Waterers and Watering Systems:

A Handbook for Livestock Producers and Landowners

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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Kansas Grassland Water Quality Stewardship Program, Dept. of Agronomy, Kansas State University

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This handbook will also be available in a smaller printed form as Kansas State University Agricultural Experiment Station and Cooperative Extension Service publication S-147. Ordering information is available at *http://www.oznet.ksu.edu/library/* or by calling (785) 532-5830.

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Cattle defecate in the water and erode the streambank and pond edge.

Introduction

Why should I be concerned about where my cattle drink?

Livestock tend to concentrate around water sources. This activity can lead to reduced vegetative cover and increased manure concentration in and around water sources. The water source can become polluted with sediment, nutrients, and fecal coliform and streptococcus bacteria, leading to impaired water quality.

How can I change my livestock drinking and loafing behavior?

Livestock distribution can be altered by manipulating livestock attractants. Water is the strongest attractant, both for drinking and loafing. Other attractants are 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 or adding attractants or redistributing them can alter cattle drinking and loafing behavior.

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. 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.

Cattle spend as little as 4 minutes a day actually drinking but can spend 10 times as long loafing around the water source.[1] Loafing activities increase the water quality problems associated with water distribution points. These distribution points can be made less attractive for loafing by removing nearby attractants, placing other attractants well away from the distribution point, and by making the distribution point less comfortable or less easily accessible for loafing.

Providing a water source away from a stream can reduce time spent by cattle in the riparian area by up to 96 percent. Providing shade away from streams can also reduce the amount of time cattle spend in the riparian area.[2]

[1]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.

[2]Byers, H.L, M.L. Cabrera, M.K. Matthews, D.H. Franklin, J.G. Andrae, D.E. Radcliffe, M.A. McCann, H.A. Kuykendall, C.S. Hoveland and V.H. Calvert II. 2005. Cattle use of riparian areas in the Georgia Piedmont, U.S.A. J. Environ. Quality 34:2293-2300.

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

How is water made available to animals?

There are three main options for providing water to animals:

- direct access to a water source
- gravity flow from a higher elevation
- pump from a lower elevation

Do animals have a preference about where they drink?

Several studies have examined drinking preferences. Hay-fed cattle have been shown to prefer drinking from a trough rather than a stream[3]. Crawford et al. (2001) found no differences in cattle preference for pond vs. well water, even though the pond water had high levels of fecal coliform bacteria[4]. Another demonstration study[5] found that 76% of the time cattle drank from a tank rather than a pond when both were available; tank water had much lower levels of suspended solids (sediment) than pond water.

How do livestock respond to water quality?

Livestock may respond to fecal contamination of water quality by reducing water intake[6]. This may affect production through reduced feed intake.

[3]Miner, J.R., J.C. Buckhouse, and J.A. Moore. 1992. Will a water trough reduce the amount of time hay-fed livestock spend in the stream (and therefore improve water quality)? Rangelands. Soc. for Range Management. 14(1): 35-38.

[4]Crawford, R.J., and E. Cole. 1999. Effect of water source and quality on water intake and performance of cows and calves grazing tall fescue. 1999 Research Rep., Southwest Missouri Agric. Res. Education Center, Mt. Vernon.

[5]Suber, G., K. Williams and M. Manoukian. 2006. Drinking water quality for beef cattle an environment friendly and production management enhancement technique. Beef: questions and answers. Montana State University Extension and Montana Beef Council, Bozeman.

[6]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(5):452-460.

How do I decide which option to use?

The purpose of this handbook is to assist you in choosing a watering system that fits your budget and needs. Some systems will only work in certain situations. They may 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 landand site, the time you have available for management and upkeep, and the size and type of animal you have. These will all factor into your decisions about which option to choose.

Water Sources Comparison Chart

Source	Primary Advantage(s)	Primary Disadvantage(s)	Estimated Cost
Stream	Naturally occurring, no direct installation cost	Water may become stagnant and of poor quality in low flows; can increase levels of fecal coliform and other bacteria in water	None for unrestricted access
Pond	Does not involve mechanical or electrical parts that can fail; often used for fishing and other recreational activities	Direct livestock access can cause poor water quality; cost of initial construction and restoration is high	$3,000 or more
Developed Spring	Relatively inexpensive; small flows can be turned into a valuable water supply	Springs may not be present	$1,000 or more
Horizontal Well	Can access a significantly larger water-bearing zone than normally can be accessed with a vertical well bore hole	Local well drillers may be unfamiliar with the process; horizontal well drilling equipment may not be readily available	$10/ft. to drill; small submersible pump $350; pump casing $150; 4" PVC pipe $1/ft.; total well cost $1,500 - $2,500 (higher figure includes electricity hookup)
Wet Well	Simple and inexpensive; less sediment and fewer nutrients entering streams and ponds	Stream access required; may require rented equipment or a contractor to install; few examples in Kansas	$1,500- $2,500 installed
Drilled Well	Water quality from wells is usually quite consistent; typically has a long useful life when regularly maintained	Groundwater may be deep, making well drilling expensive; aquifer may not be present	$15-30/ ft. to drill; $500-$1,000 or more for a pumping system
Water Harvesting	Useful in areas where natural water sources are scarce; can be located in extremely remote areas where other water sources are impractical	Water quantity is dependent upon rainfall and harvested area; most useful for small numbers of livestock	Dependent on type; $300 for small self-supporting structure
Rural Water District	Rural water district supplies are generally reliable with few interruptions or outages; water is treated and meets public water supply standards	Not available at all locations; minimum water use charges even during time when water is not used; membership and/or meter fees	Depends on distance from water main to distribution point; $1,000-$2,000 or more plus monthly fees
Hauled Water	Very mobile; allows short-term grazing of temporary forage supplies such as crop residue	Hauling water is labor intensive; muddy or snowy conditions can complicate or even prohibit water delivery	Used anhydrous tank and trailer can be purchased for about $500; recurring labor and fuel costs

Water Sources

Stream

Overview

Small streams are a common source of livestock water in Kansas. While there are some advantages, you should carefully consider other issues, such as concerns about reliability, bank erosion and water quality. Special steps should be taken to minimize these problems if livestock will be given direct access to streams.

Advantages

- Naturally occurring, no direct installation cost
- Water normally clean and fresh
- Hardened surface access points can be used to minimize animal damage
- May provide a vehicle crossing point

Limitations

- Susceptible to bank erosion
- Potential injury to livestock slipping on banks or getting caught in tree roots
- Needs regular repairs to water gaps after floods
- Serve as attractants that can cause heavy use of riparian areas and poor grazing patterns
- Flow may be seasonal and stop during dry periods
- Water may become stagnant and of poor quality in low flows
- Increases levels of fecal coliform and other bacteria in water

Stream

Design Considerations

Restricting access to specific points along a stream should be a primary goal. This will eliminate most of the bank erosion caused by livestock traffic as well as potential livestock injuries. Develop access ramps or trails with hardened surfaces such as coarse gravel over geotextile and slopes of 6:1 or flatter. These should allow easy access to pools within the stream that livestock prefer over riffles. Locating shade, salt, minerals, and winter feeding sites in portions of the pasture away from the stream will help reduce the time livestock spend at or adjacent to the water. Refer to the "Limited Access Watering Points" section (p. 97) for additional design information.

This practice may require permits. Please read the permit section of this handbook (p. 143).

Pond and Pit

Overview

Ponds are the most 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 like recreation and flood control. However, concerns about sedimentation and water quality justify consideration of alternate water sources.

Advantages

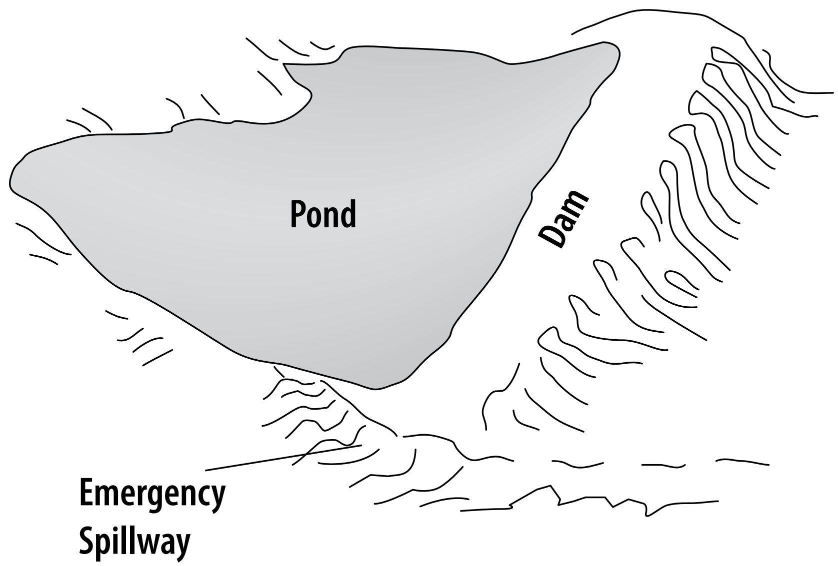
- Simple and adaptable to many locations
- Will generally store a long-term supply
- Multiple examples and experienced contractors readily available
- Does not involve mechanical or electronic parts that can fail
- Often used for fishing and other recreational activities
- Often designed for detention of heavy runoff to reduce flooding downstream

Limitations

- Sedimentation and bank erosion limit life of reservoir storage
- Direct livestock access can cause poor water quality
- Initial construction and later restoration costs are high
- Steep banks are hazards to livestock when muddy
- 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
- Erosion in emergency spillways is a common problem
- Runoff needed to refill the reservoir will be limited and sporadic in low rainfall area
- Generally not suitable for sandy or rocky soils
- Ponds that do not hold water are difficult to remedy

Longitudinal Section
(not to scale)

Cross Section
(not to scale)



Pond or Pit

Design Considerations

Most ponds are constructed by excavating material that is used to build an embankment (dam) across an incised drainage. Reservoir size is a result of the natural depth of the drainage and excavation of material for the dam. In broad, flat drainages, it may be necessary to create a reservoir by simply excavating a pit. Pits may also be built outside of drainages in situations where they are supplied by underground flow.

Size and location are critical factors when designing livestock ponds. Ponds should be large enough to store enough water to supply livestock for extended dry periods (generally two years) of high evaporation and no runoff – with the exception of ponds supplied by springs and underground flow. Embankment ponds usually include a primary spillway or trickle pipe for controlled release of detention water as well as a flat emergency spillway at the end of the dam to carry excess water during high rainfall events. Sizing the trickle pipe and detention storage relative to the size and slope of the drainage will protect the emergency spillway from repeated flows and erosion.

Ponds should be located in areas that get less grazing pressure from livestock – opposite prevailing summer winds and away from shade, streams, salt and mineral sites. Dams and other disturbed areas should be reseeded soon after construction. Installation of water supply lines under or through the dam and fencing will improve water quality and extend the life of the pond. Properly designed ponds of minimum size generally cost at least $3,000 and larger ponds much more. Assistance with detailed designs is commonly available through local NRCS and conservation district offices.

This practice may require permits. Please read the permit section of this handbook (p. 143).

Dams can also involve water rights. For more information, check *http://www.ksda.gov/Default.aspx?tabid=324*.

The landowner is responsible for the safe operation and maintenance of the dam. When siting a dam, consider downstream development that would be affected if the dam should fail.

Developed Spring

Overview

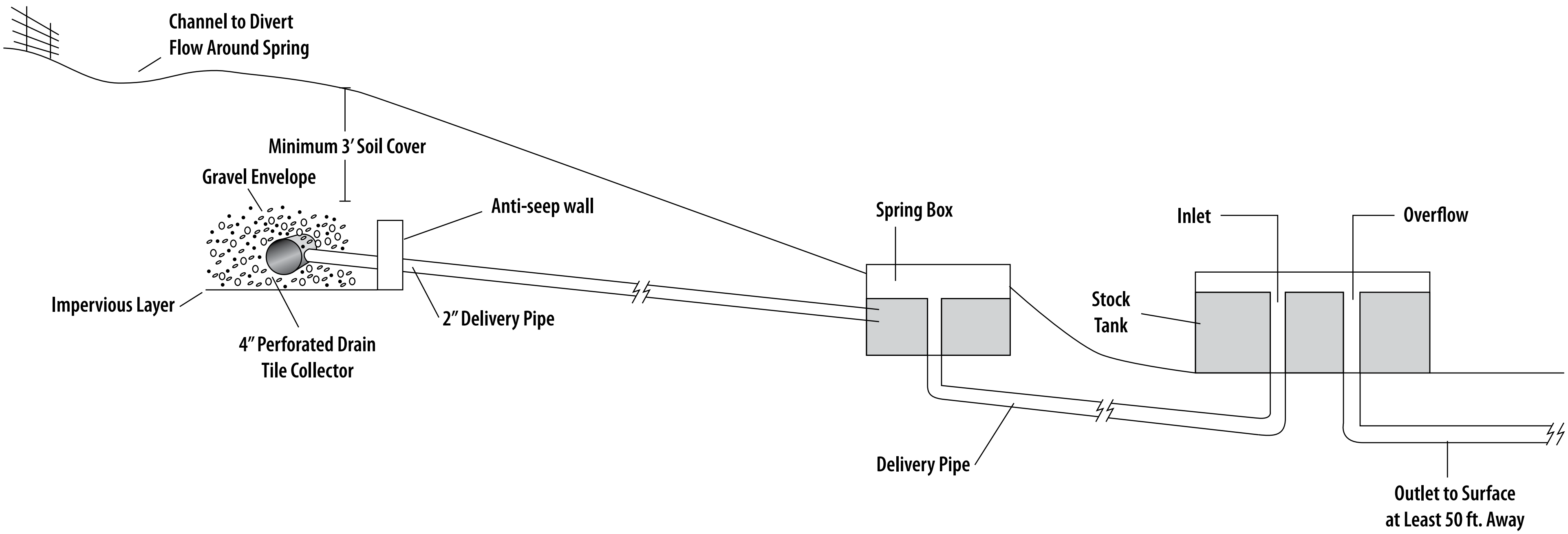
Spring development is a relatively inexpensive investment compared to a well or farm pond to provide water for livestock.

Advantages

- Improved water quality for livestock
- Reduced risk of injury to livestock falling through ice in winter
- Relatively inexpensive
- Even small flows can be turned into a valuable water supply
- May be possible to develop without electricity
- May be possible to develop with on-farm supplies to reduce cost

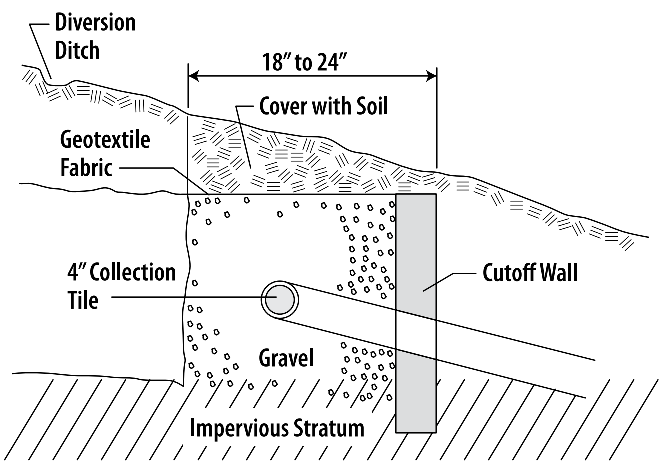
Limitations

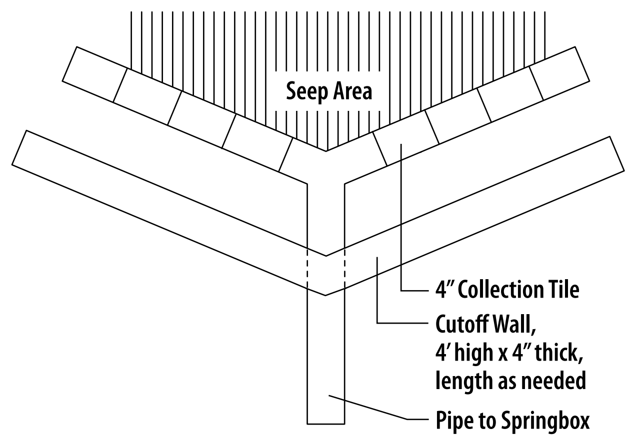
- Springs occur naturally and in limited areas
- A small spring requires construction of storage capacity to have a reliable supply of water
- Supplemental power is required if water is to be pumped uphill
- The spring should be protected from livestock disturbances
- Careful design, planning, and construction are required for a clean, reliable supply of water
- Spring flow may decline or stop during drought



21a. Concentrated Spring

21a. Low-area Spring





Developed Spring

Design Considerations

Even small flows can be developed to water livestock. At a minimum, a spring should have a year-round flow rate of at least one gallon a minute. With proper storage, this minimum flow can water nearly 100 cattle. It is important to monitor the spring flow through the different seasons of the year. You can consult older neighbors or previous owners about a spring's dependability as a water source.

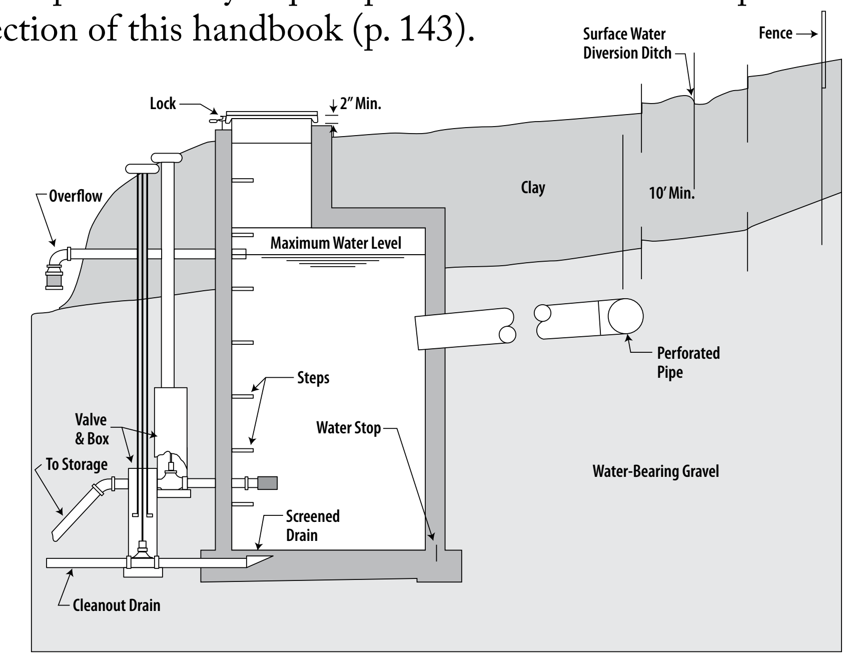
For springs located on slopes or ridges, it may be possible to pipe the water to a series of tanks in multiple pastures downhill. While year-round springs are preferred, "wet weather" springs may be satisfactory if the pasture is used for early intensive stocking. In this case the springs generally produce until the hot, dry period in July and August. The same principal may apply to pastures used for winter grazing when most of the vegetation is dormant and there is little evaporation.

Proper management of the landscape around the spring can conserve the quantity and quality of the water. While you can't increase the total water flow available, you can remove cattails, shrubs and trees to 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.

The landscape around the spring should be shaped to divert surface water runoff. If an underground collection trench is chosen, 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" or larger. This pipe should be surrounded by a fabric filter and washed rock. The water can then be piped to a storage container or directly to a downhill livestock water tank. The collection trench would be covered with clay and mounded to prevent surface water infiltration.

To properly design a spring-fed watering system, contact your local NRCS field office for technical construction details so you will be assured of having a low-maintenance and dependable watering system.

This practice may require permits. Please read the permit section of this handbook (p. 143).



Horizontal Well

Overview

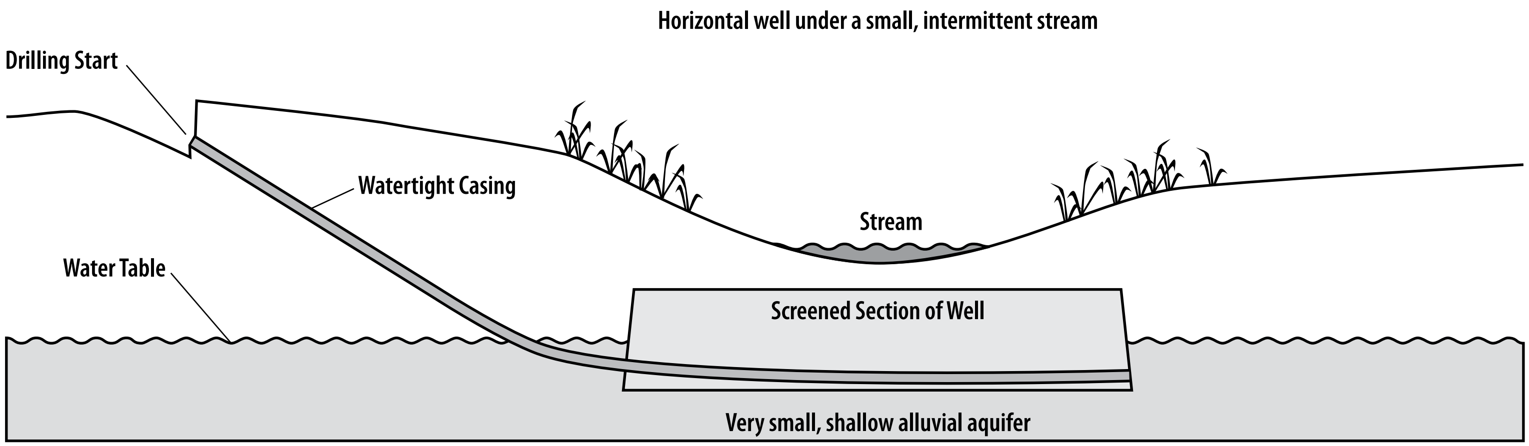
Horizontal well drilling and directional boring technology have been commercially available in the petroleum industry since the late 1980s. They have steadily grown in use and acceptability in many other fields, including utilities, hazardous waste clean-up, and water wells. In the oil industry, horizontal wells have produced at 2.5 to 7 times the rate of vertical wells. Conventional water well drilling equipment can be modified to drill in a horizontal direction. Horizontal water wells have been used in arid and semi-arid parts of the U.S. to access water bearing formations from the side of a hill. This installation method reduces drilling depth and casing length while extending the well screen length to access a larger percentage of ground water-bearing strata.

Advantages

- Can access a significantly larger water bearing zone than can be normally attained with a vertical well bore hole
- Works well in low rainfall areas
- Can be drilled into the streambed without disturbing the stream
- Often offers a shorter drilling length and thus a less costly method of reaching water bearing strata compared to drilling from the top of the hill.

Limitations

- Local well drillers may be unfamiliar with the process
- Horizontal well drilling equipment may not be readily available


Horizontal well under a small, intermittent stream
Drilling Start
Watertight Casing
Stream
Water Table
Screened Section of Well
Very small, shallow alluvial aquifer

Horizontal Well

Design Considerations

Although horizontal wells can be used effectively in any rainfall region, they have been found to be especially beneficial in regions where rainfall and associated groundwater recharge are minimal and infrequent. Some important factors for a good horizontal well site include:

- **Geology and topography** – geological formations with a fairly shallow groundwater bearing zone or stratum, with adequate surface space and terrain to move and run the equipment
- **Alluvial sites** – deep enough without major rock excavation required to install ground water collection trenches
- **Location** – close to a power source to operate pumping equipment and away from drainage ditches or other features (such as rock outcrops) that could cause periodic flooding, sedimentation, falling rock damage, or interference with use of the system

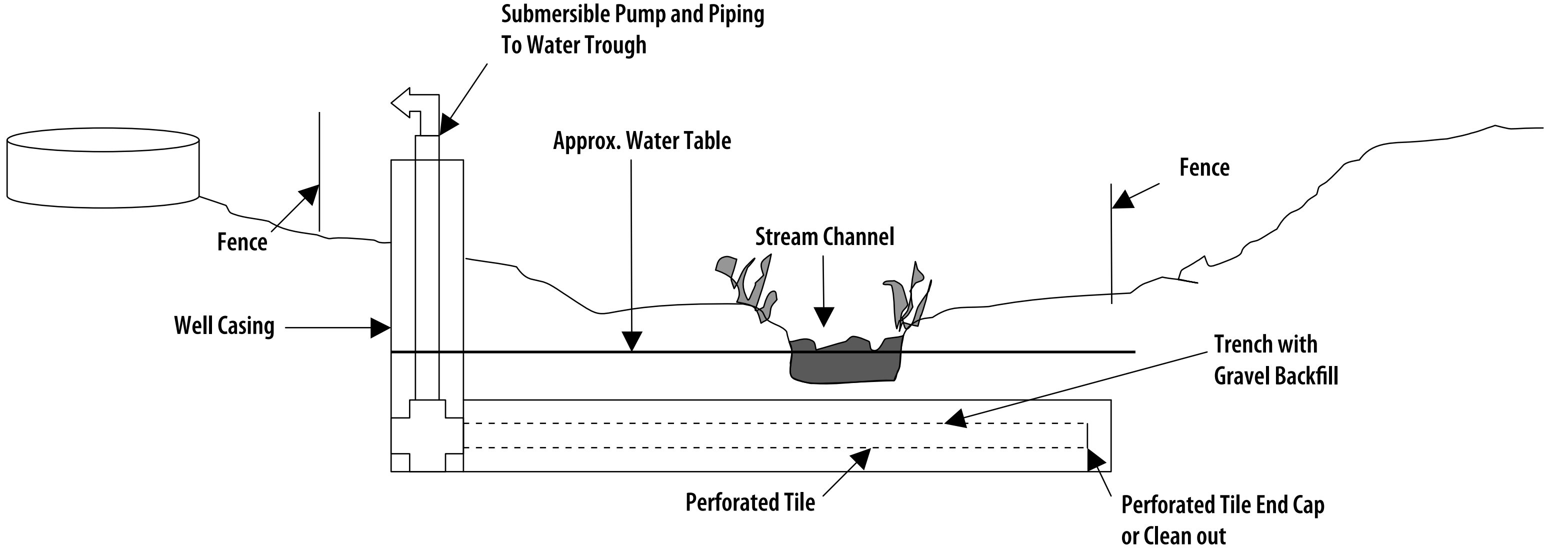
The area around the well field, especially an excavated stream installation, should be fenced to restrict grazing animals and associated manure contamination and to prevent damage to the well field and stream bank by hooves and milling animals.

Principal considerations for a horizontal well include a well screen and gravel pack, a pump and casing, and maintenance.

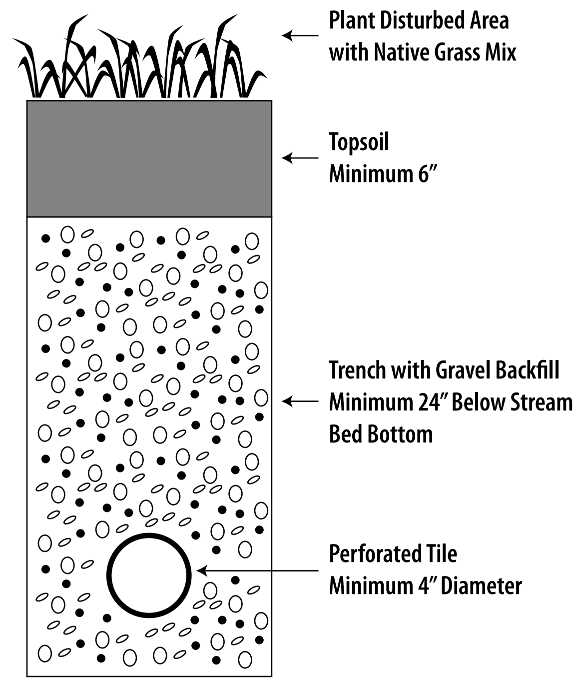
Well screen and gravel pack: The well screen is one of the most important components and can be made of various materials, including stainless steel, steel, clay tile, or plastic pipe. The gravel pack is equally important to filter incoming water and protect the screen and well casing from plugging. In low-budget agricultural installations, perforated high density polyethylene (HDPE) corrugated tubing works well for the well screen and comes in various standard sizes from 3 inch to 24 or more inches. HDPE is ready available for other agricultural uses, such as tile drainage or lateral lines, and comes with a filter sock. The filter sock is not recommended in most horizontal well applications because of plugging.

The gravel pack should be made from permeable materials such as river rock or crushed limestone. In locations where there are plugging problems with water borne clays and silts, the gravel pack is designed and constructed with multiple sizes of aggregates to filter the clay and silt particles without plugging the screen. A standard-sized gravel-pack material for a directionally drilled system is 3/8-inch diameter and smaller gravel; for a trench excavated system, 1/2-inch diameter crushed stone.

The diameter of the well screen and gravel pack is limited to a maximum of a 4-inch diameter screen with 1- to 2- inch gravel pack for most horizontal drilling equipment. Larger sizes can be installed but the cost may be prohibitive. Because the well screen and casing are pulled through the borehole by the drilling equipment, the gravel pack comes pre-assembled (glued) with the screen and is installed with the screen.



Horizontal Well Installation – Excavation Option



Horizontal Well

In an excavated-trench installation, the size of the well screen can be much larger as the gravel is added separately. Gravel should be installed six inches below the flow line of the HDPE tubing, and a minimum of 24 inches above the tubing and below the established water table. The size of the screen and trench excavation, and the amount of gravel installed, can also be expanded horizontally and vertically to create more groundwater storage within the well field. (See "Supplemental Materials" section of this handbook, p. 135).

Pump and casing: Submersible water pumps work well in horizontal wells. Power for the pump can come from a dedicated power line, a natural gas/propane or gasoline/diesel combustion engine, solar power, or a windmill. The diameter of the well casing should be several inches larger than the diameter of the pump casing, and approximately 1½ times larger than the horizontal well screen. The top of the well casing should be capped and elevated at least 12 inches above the existing ground around the casing to avoid contaminants entering the casing. The bottom of the casing should be set below the inlet flow line from the well screen to create a sump for setting the pump with adequate water depth. The bottom of the sump should also allow at least 6 to 12 inches below the pump inflow elevation to store accumulated sediments. Several ranch supply and hardware stores carry prefabricated well sumps and junction boxes that are designed for HDPE installations.

Maintenance: The well field, piping and screen should be periodically inspected to ensure that pipes and screens are not clogged. A clean-out cap can be installed at each end of the pipe to flush debris and sediment from the piping and screen. If a clean-out is desired, it should be installed when the trench is excavated and the screen and piping are installed.

Well drilling is regulated by the Kansas Department of Health and Environment, Bureau of Water, Geology Section. Wells should be drilled by a licensed waterwell contractor according to state waterwell regulations (*http://www.kdheks.gov/waterwell/*). Some counties have additional well drilling regulations and may require permits. State law requires that abandoned water wells should be plugged (*http://www.kdheks.gov/waterwell/download/WWC-5P.pdf*).

This practice may require permits. Please read the permit section of this handbook (p. 143).

Wet Well

Overview

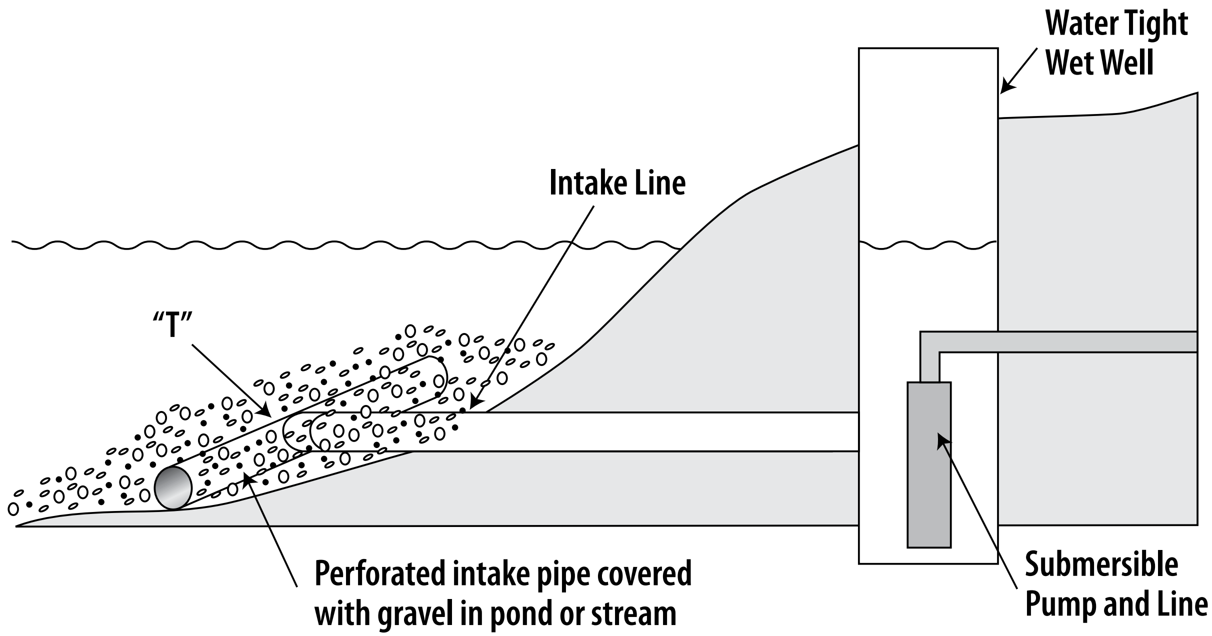
In many locations, the chance of finding usable water when drilling a well is unfavorable. In those areas, ponds and streams may be available to serve as sources of water. In order to use the water supplies for livestock, it may be desirable to install a pumping system. Placing water intakes directly into the stream can allow them to be damaged or lost when flooding conditions occur. A wet well serves as an ideal location to install a pump or intake line. A wet well allows intake through a wide range of stream flow or depth.

Advantages

- Simple and inexpensive
- Reduced bank erosion
- Less sediment and nutrients entering streams and ponds
- Extended pond or stream usefulness
- Reduce the maintenance of a pumping site
- Extends the life of a pump installation
- Improves the quality of water pumped to livestock

Limitations

- Specialized equipment may be necessary for installation
- Few examples in Kansas to use as references


Water Tight
Wet Well
Intake Line
"T"
Perforated intake pipe covered
with gravel in pond or stream
Submersible
Pump and Line

Wet Well

Design Considerations

In order to supply water to livestock away from the stream or pond, it often is necessary to install a pumping system. A wet well can protect the pump from damage when water depth varies or during flood conditions. The wet well is a water intake system that allows the stream or pond water to flow from the stream or pond to the artificial well.

Various materials can be used; the choice most likely will depend upon local availability.

Wet well systems typically can be constructed using an excavator or backhoe. The well is constructed by digging a hole, deeper than the water source, at a distance of 15 feet or more from the edge. A casing is then placed in the hole. The correct casing size is determined by the flow rate of the stream, the pumping rate desired, and the type of pump to be used. In some cases a perforated culvert tube can be installed as the casing. In other cases, a standard 6" or 8" perforated well casing is used. The intake medium is then installed around the base and sides of the casing.

After the well casing is installed, a trench is dug between the water source and the well hole. A filter medium or plastic pipe is installed in the trench to transport water from the source to the well. The depth of the trench should be equal to or below the bottom of the water source. Coarse sand or river gravel are desirable filtering media. A plastic or PVC line is also acceptable. A large basin around the well casing filled with a clean, uniform gravel-sized medium can serve as a reservoir for storing water near the casing.

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

If a filtering medium is used, some references recommend using a filter fabric barrier between the medium and the soil layer to prevent fines from accumulating, thus extending the life of the medium.

Once all the lines and media are installed, soil can be replaced on the surface and reshaped. Soil can be replaced over and around the wet well. Raising the soil around the wet well improves its functioning.

Well drilling is regulated by the Kansas Department of Health and Environment, Geology Section. Wells should be drilled by a licensed waterwell contractor according to state waterwell regulations (*http://www.kdheks.gov/waterwell/*). Some counties have additional well drilling regulations. Abandoned water wells should be plugged (*http://www.kdheks.gov/waterwell/download/WWC-5P.pdf*).

This practice may require permits. Please read the permit section of this handbook (p. 143).

Drilled Well

Overview

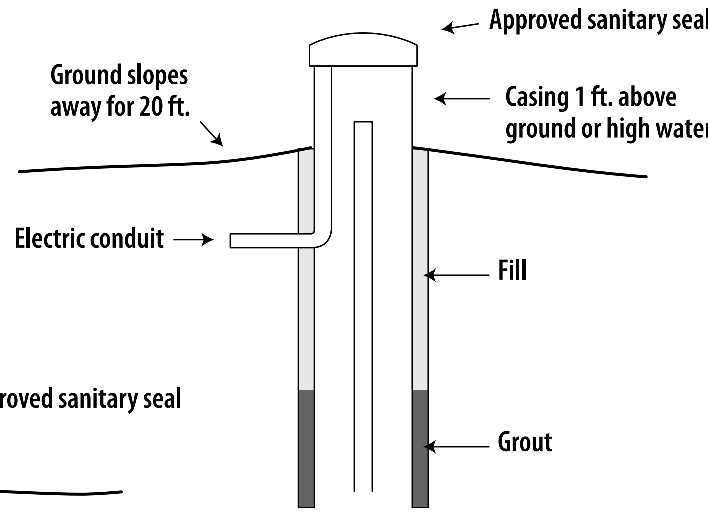
Historically, wells have been the water source of choice for homes and livestock. In areas where groundwater is available, a well usually is the easiest method to obtain a reliable, high quality water source. About 50 percent of Kansas is covered by principal aquifers that reliably yield enough water to supply a well. In areas where principal aquifers are not found, local aquifers may provide adequate water for a small well.

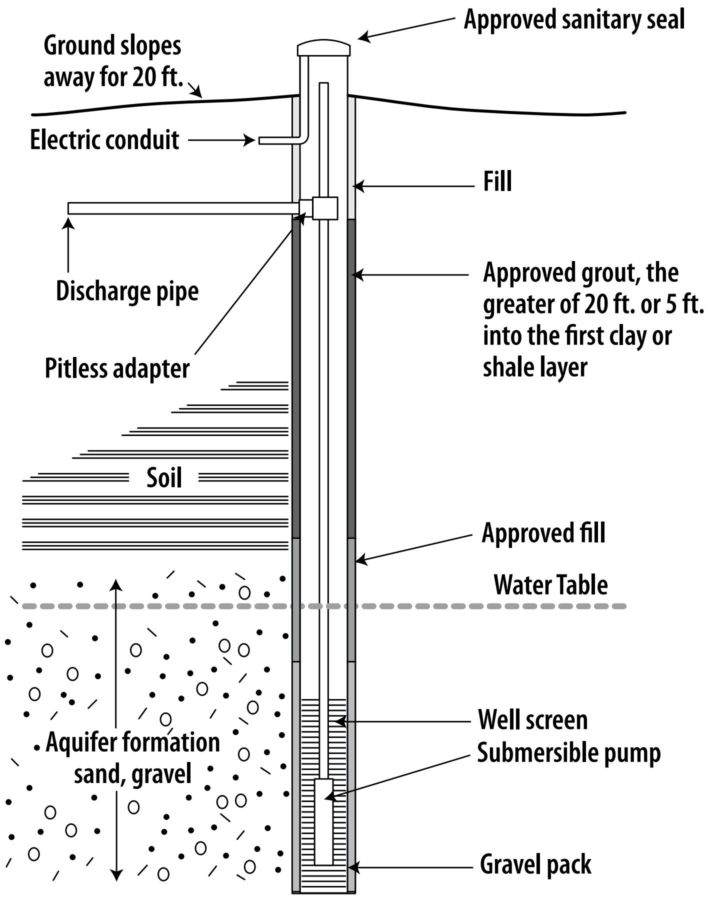
Advantages

- Aquifer supplying a well is not subject to water losses, such as evaporation or seepage
- Soil cover protects the aquifer that supplies a well from contamination
- Usually provides the shortest distance from a water source to the place of use
- Not subject to freezing
- Water quality is usually consistent; changes are very slow over time
- Typically has a long useful life, especially when maintained and protected

Limitations

- During extended drought, water levels drop and well yield may decline or well may go dry
- In some areas, groundwater may be quite deep, requiring a deep, expensive well
- Drilling too deeply yields brackish water in many areas of Kansas
- No aquifers to supply wells in large areas of East-central and Southeast Kansas
- Test holes, poor or unused wells, or surface activities have polluted groundwater in some areas
- Groundwater easily polluted by careless actions or lack of well protection
- Groundwater in aquifers is usually moving, so changes in well-water quality may occur


Approved sanitary seal
Ground slopes away for 20 ft.
Casing 1 ft. above ground or high water
Electric conduit
Fill
Grout


Approved sanitary seal
Ground slopes away for 20 ft.
Electric conduit
Fill
Discharge pipe
Approved grout, the greater of 20 ft. or 5 ft. into the first clay or shale layer
Pitless adapter
Soil
Approved fill
Water Table
Aquifer formation sand, gravel
Well screen
Submersible pump
Gravel pack

Drilled Well

Design Considerations

Animals may perform better with good quality water. Safe water wells are those that meet today's location and construction standards. Wells constructed before 1975 rarely meet these standards and many are sources of groundwater pollution.

Kansas well drillers are licensed by KDHE and must use well components that meet state standards. Drilled wells must meet the criteria listed below to comply with current location and construction standards.

- The location should be upslope and away from contamination sources. Many wells are polluted because of inadequate separation or a location downslope of activities that directly effect it.
- A watertight casing extends at least one foot above the ground surface to prevent the entry of surface water with contaminants. Sites subject to flooding should be at least one foot above the highest flood level. The casing must be watertight from the top to the intake screen, which should be below the water table. No holes are permitted in the casing except for an approved pitless adapter, which must be sealed to the casing.
- An approved grout seals the casing to the borehole from the surface to 5 feet into the first clay or shale confining layer or 20 feet below surface, whichever is greater. The grout also must be placed adjacent to all confining layers to separate water-bearing layers. Approved grout includes bentonite clay, neat cement and cement-water slurry.
- An approved pitless adapter is used to prevent freezing unless a pump house is used. The adapter enables a watertight connection through the casing below frost level. An approved pitless unit also may be used to replace the top portion of the casing. The pitless unit attachment to the casing is watertight. The unit also has a connection to the water line below frost level.
- An approved sanitary seal must cap or plug the top of the casing to prevent entry of contaminants. This seal must be securely attached to the well casing so it is tight and prevents the entry of water and insects. A screened vent on the seal allows air to enter so the casing does not collapse and prevents the entry of insects and debris.
- Slope the ground surface away from the well to prevent water ponding within 50 feet. The slope should be at least 6 inches within the first 20 feet from the well to assure positive drainage.

Maintenance is essential to assure that the well continues to meet all location and construction standards. Components should be checked at least yearly using guidelines in *Private Well Maintenance and Protection, MF-2396* (a K-State Research and Extension Service publication). The well should be cleaned and disinfected by shock chlorination following the procedure in *Shock Chlorination for Private Water Systems, MF-911*. A water test after maintenance is recommended to assure that no contamination is entering the well.

Finally, many wells have been polluted by careless and thoughtless actions. This is best prevented by a fenced exclusion zone where no contaminants are allowed. Outside the exclusion zone, a management zone should provide additional protection if contaminants are allowed here.

Drilled Well

Well drilling is regulated by the Kansas Department of Health and Environment, Bureau of Water, Geology Section. Wells should be drilled by a licensed waterwell contractor according to state waterwell regulations (*http://www.kdheks.gov/waterwell/*). Some counties have additional well drilling regulations and may require permits. State law requires that abandoned water wells should be plugged (*http://www.kdheks.gov/waterwell/download/WWC-5P.pdf*).

This practice may require permits. Please read the permit section of this handbook (p. 143).

Water Harvesting

Introduction

Water guzzlers are passive, artificial stormwater collection and watering devices that have been developed for arid and semi-arid parts of the west where water can be a limiting factor in development of wildlife habitat. Originally, they were referred to as "gallinaceous guzzlers" for Galliformes, the order of birds that includes quail, grouse, turkey, and pheasants. "Guzzle" refers to the sound made by the birds when they drink from a pool of water. Guzzlers also provide water to other creatures that require surface water for survival, including many amphibians and mammals and some reptiles and invertebrates. Water guzzlers are beneficial to livestock when they are large enough to provide adequate water supplies for larger animals (such as cattle) or during short-term use of extremely arid rangelands.

Water harvesting systems placed on sloping ground that collect runoff water for storage and transfer to a watering point have been used in arid rangeland areas.

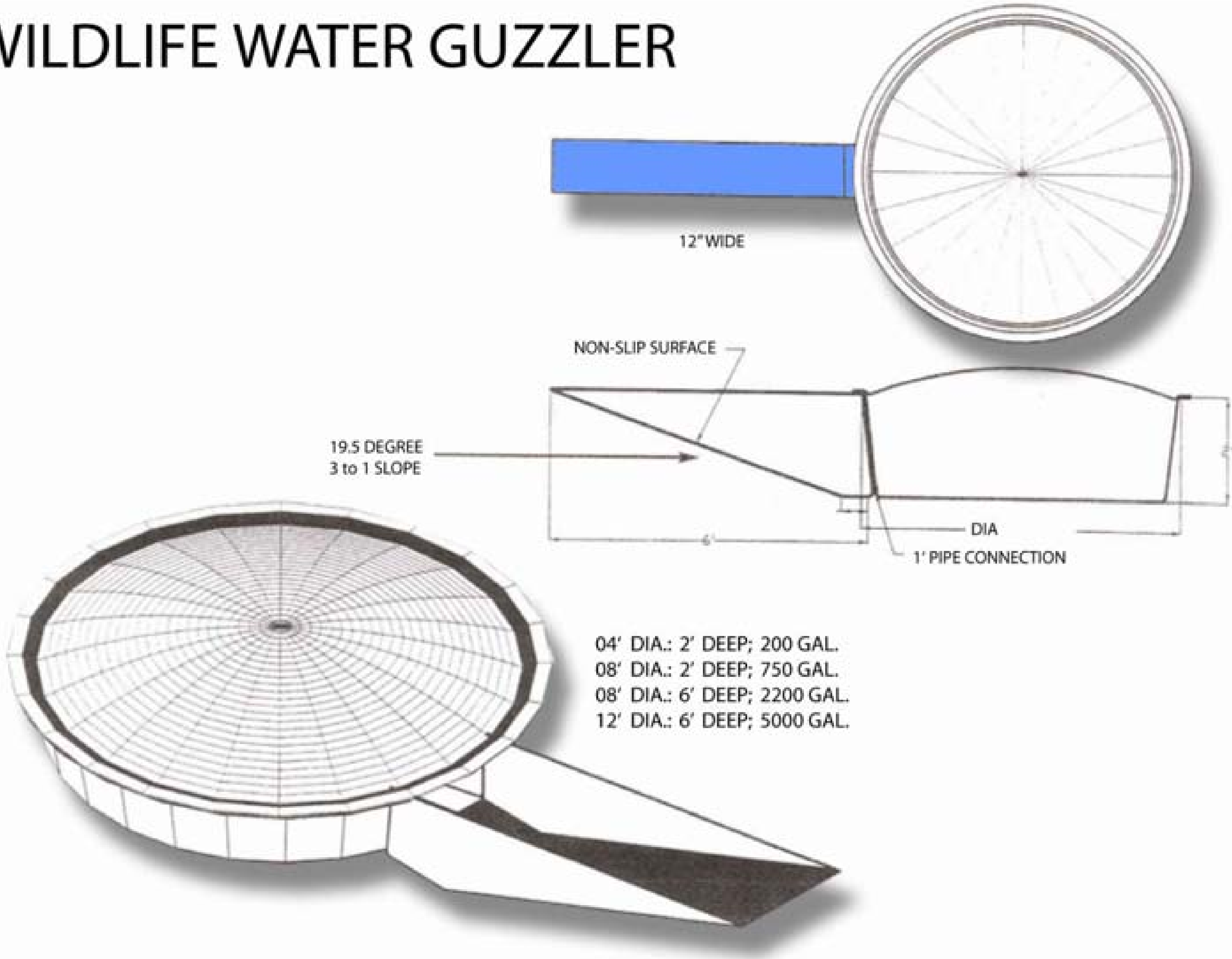
Advantages

- Useful in areas where natural water sources are scarce
- Can be made of inexpensive or recycled materials
- Easily installed
- Minimal site preparation
- Can be located in extremely remote areas where other water sources are impractical
- Minimal upkeep expense and labor

Limitations

- Water quantity is dependent upon rainfall
- Most useful for small numbers of livestock

WILDLIFE WATER GUZZLER



Design Considerations

Although water guzzlers can be effectively used in any rainfall region, they have been found to be especially beneficial in regions where rainfall is minimal and infrequent. Many federal agencies and wildlife organizations have established wildlife watering programs in arid states such as Nevada, Utah, Colorado, Arizona, Texas, and New Mexico.

Some of the important factors for a good guzzler site include:

- Site with little topographical relief, slope of 1 percent or greater, and adequate expanse of fairly flat surface area to collect a usable amount of water
- Adequate soil depth to bury the water storage tank and provide an access ramp or port
- Location away from drainage ditches or other features, such as rock outcrops, that could cause periodic flooding, sedimentation, falling rock damage, or interference with use of the system.

The principal elements of a guzzler system include the rainwater/snow collection surface or apron, a water storage tank, an animal access ramp or port, a water control orifice or valve, fencing, and maintenance.

Rainwater/Snow Collection Surface or Apron: The collection surface (apron) is made of impervious surfacing materials such as corrugated metal sheeting, UV protected plastic sheeting, fiberglass sheeting, asphalt paving, or any other suitable material that is economical to buy and install. Aprons can be constructed on the ground surface or elevated with a support structure. Support structures normally require more thought concerning loading factors to properly size the support beams, columns, etc. Ground construction is normally less expensive than constructing supports. However, site conditions (such as a rocky surface) may require that the apron be elevated with supports.

If the watering facility is located next to an existing building with appropriate roofing material, then the roof would provide an opportunity to collect the rainwater or snow melt through a gutter/downspout system similar to a cistern. However, most watering facilities are located long distances from buildings and electricity, and therefore, the typical water guzzler is normally considered to be a stand alone watering facility.

The location and size of the apron is a function of the existing topography, soil type, and desired amount of water to be captured at each guzzler. Normally, the ratio of drainage area to storage volume is a function of the annual rainfall and snow for the region. This information can be found through the local NRCS office or published soil survey report. Water yield can generally be estimated as 1 ft^2 of apron/gallon of water/1.6 inch of rain (less for snow).

Water Harvesting

Typical water yields per square foot would be:

Apron size	Annual Water Yield (gal.)
20’ x 20’	4,800
40’ ft. x 40’	19,200
100’ x 100’	120,000
1 acre	520,000

For example, a guzzler located in an area with 20 inches of average annual precipitation would have an expected yield of approximately 12 gallons of water/ft^2 of apron area. Runoff estimates are reduced by 5 percent to reflect evaporation and small apron transmission losses.

Water storage tank: The size of the water storage tank is a function of two important factors. Those are the amount of water needed (gallons of water per head per month) and the amount of water being delivered (average rainfall per month).

An additional one-month supply is normally required as a safety factor for periods of no rain or runoff. Storage tank sizes typically range from 200 to 5,000 gallons.

The water storage tank is normally buried but can be above ground or partially elevated where the apron is either located at a higher elevation or elevated by ground supports above the level of the tank. Below-ground tanks should be constructed of corrosion resistant materials such as plastic, fiberglass, or cathodically protected metal. Above-ground tanks are constructed of UV protected plastic, galvanized metal or similar weather resistant materials. Below-ground installations are usually preferred because they provide insulation by soil and easy access for animals. Covering tanks reduces evaporation losses and prevents foreign matter such as dirt, leaves, and bird droppings from contaminating the water.

Animal access ramp or port: Depending on the final elevation of the tank, an opening and ramp should be provided to allow animals adequate room and secure footing while drinking. If a ramp is constructed, it should be no steeper than 190 degrees or a 3:1 slope. Gentler slopes are preferred if the site allows (in the absence of shallow rock).

The ramp width is normally a function of the number of animals that need access at one watering event. An access port of 4 or 5 feet will accommodate three or four cattle. Wider openings are not recommended because increased water surface area increases evaporation losses and contamination by dust and debris. The ramp surface and subgrade should be constructed of materials similar to those used around water troughs and watering structures. The entrance to the watering port should be slightly elevated with an earth-grassed berm. This helps keep surface stormwater contaminated with sediment and animal droppings from being washed into the drinking water.

Water control orifice or valve: A orifice, pipe, and/or valve from the storage tank to a separate drinking device is preferred when large numbers of animals need water. If power is available at the site, a water pump can be used to move water into troughs or other drinking devices. Otherwise, gravity-flow systems must be used.

Water Harvesting

Fencing: The area around the apron and storage tank should be fenced to restrict grazing animals and associated problems of contamination by droppings and damage to the apron and tank system by hooves and milling animals.

Maintenance: The apron and ramp areas should be cleaned of debris, animal droppings, and other water pollutants quarterly and more frequently if the areas are not fenced. Tank, piping, valves, and other structures should be periodically checked to ensure that they are functioning correctly. Water storage levels should be checked to make sure there is an adequate supply for livestock.


TREGO RWD 2

Rural Water District (Public Supply)

Overview

People who live in town most commonly receive water from a public water system. Rural water districts, a type of public water supply, deliver water to rural areas and many small communities. Kansas is a national leader in the number of rural water districts with a long history of solving water supply needs in rural areas. Rural water districts are generally a reliable source of water that meets U.S. EPA safe drinking water standards. This section addresses rural water districts as a source for livestock water.

Advantages

- Generally reliable with few interruptions or outages
- Producers need not be concerned about power outages and equipment failure
- Water is treated and meets public water supply standards – a higher standard than generally needed for livestock
- Districts are concentrated in central and eastern Kansas, where principal groundwater aquifers are absent or water quality is poor
- Water is delivered under pressure that should satisfy most needs

Limitations

- Water lines typically run along roads where more people live, so district water is not available in all locations
- If a line is not adjacent to the property where water is needed, there may be a cost to extend the line
- Long line may be required on property to deliver water from the meter to the points of use
- Building and operating a rural water system with long supply lines is expensive, often making cost of rural water higher than producers want to pay for livestock water
- Existing rural water line may not have capacity to add another user

Rural Water District (Public Supply)

Design Considerations

There are several things to consider during the typical process of obtaining and paying for a connection to a rural water district supply.

Application for connection and fee: 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 water lines have been laid the connection cost increases because the expenses to install the system have already been paid and financed.

Extension of the water line: Most water districts do not aggressively seek to expand their systems. The main reason for this is related to finances. In the planning stage, it is relatively easy to add additional lines to serve other users and the cost is covered by grants and low interest loans shared by all. However, once the system has been built, it is often not feasible to seek grants to offset an extension to serve a few users. Typically the district is not willing to incur costs to expand because that would increase the cost for existing users. Thus a new user usually must pay the total cost for any needed extension of a water line. Depending on distance and conditions this may be substantial.

Minimum monthly cost: The district sets a minimum monthly cost for which the user is supplied a specific quantity of water. Sometimes livestock water needs are only seasonal, but the monthly cost must be paid even when the water is not needed. The amount of water delivered has little effect on the district's monthly expenses.

Cost for excess water use: The district has a charge for water used in excess of the minimum. This cost takes into consideration the cost of energy to supply the extra water and usually also an incentive for the user to conserve water as well. If users could purchase extra water for just the cost of the extra energy, they would tend to increase their use and exceed the capacity of the system to deliver 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 very small herd, a site that has an insufficient or nonexistent water source, and a site where power is expensive. Hauling water allows use of temporary or occasional sources of forage, such as crop residues.

Advantages

- Very mobile; water can be supplied to any location that can be accessed by the hauling vehicle
- Can readily supply tanks moved to new locations
- Can supply multiple sites
- Numerous auxiliary and temporary tank locations can improve grazing distribution and result in fewer livestock trails
- Can be used where installing a power source or developing a water source is cost-prohibitive
- Allows short-term grazing of temporary forage supplies, such as crop residue

Limitations

- Both a hauling tank and a vehicle are needed
- Muddy or snowy conditions can complicate or even prohibit water delivery
- Per gallon of water delivered, hauling water is labor intensive compared with many other water sources, and thus may be expensive
- Time consuming as operator must wait for tank to fill and unload in addition to hauling time; purchasing water may reduce fill time and thus total expense
- Motor fuel costs directly affect the cost of hauling water
- May need to construct access roads
- Hauling may be required daily or even multiple times a day in some cases

Hauled Water

Design Considerations

The cost of hauling water is estimated to be $1.00 per mile traveled for a 1,000-gallon load, not including the vehicle cost.

A water hauling tank should be completely enclosed so water doesn't splash out on the road. The tank can be incorporated into the vehicle, such as a recycled milk truck. A tank can be placed in the back of a pickup or truck and removed when the vehicle is needed for other purposes. Tanks can be placed on trailers, or existing tank trailers (such as those with old anhydrous tanks) can be adapted for hauling water.

The tank will need to be manually hooked up to and disconnected from a water supply. In some instances, a float can be installed to shut off the water supply when the tank is full, preventing overflows.

In some rural towns, water is available from the public water supply. This is a fast, reliable way to fill water hauling tanks. Water will cost about $0.50 per thousand gallons.

Water hauling tanks need to be fitted with shut-off valves and hoses to reach the tank where livestock will water. In some cases pumping may be required or beneficial.

Power Sources, Pumps, Pipelines and Storage Tanks Comparison Chart

Source	Primary Advantage(s)	Primary Disadvantage(s)	Estimated Cost
Solar Power	Long useful life; low operation costs and minimal maintenance	Initial cost is relatively high	$2,000+ for a complete system, including 2 solar panels
Pumps	Modest initial cost and a fairly long life	Susceptible to interruptions of the power source (electricity, fuel, wind)	$700-$800 for a submersible pump
Wind Powered Air Pressure System	The technology is simple and easy to understand, use, and maintain; system components are moderately priced, long lived, and low maintenance	Wind tends to be intermittent; water storage is important	$450-$3,500, depending on lift and volume
Windmill	Uses an abundant free energy source; well suited to sites where electricity is unavailable; has a long life (20+ years)	Dependent on steady source of wind; water storage important	New 6' windmill head costs $1,800
Animal Activated Pumping System	Simple, rugged and portable; adaptable to ponds, streams, or shallow wells; inexpensive	A unit can provide water for only about 25 cattle; pump draws water only about 20 feet vertically or 200 feet horizontally	Usually less than $500
Water Powered Pump	Relatively economical to purchase and install; no additional input energy required; relatively trouble-free operation	Requires a year around surface flow to power the pump; operation in winter may be problematic	RAM pump costs from $200 (homemade) to $2,000
Pipeline Network from Off-Site Source	Typically requires only one water source and pump to supply several outlets	Water source must be extensive enough to handle multiple waterers; professionally designed	$1+ per foot depending on size and availability of equipment
Water Storage Tank	Well suited to a system that has a steady low flow that is adequate to meet daily demand but not adequate to meet peak flow requirements; very reliable and requires little maintenance	Terrain may be unsuited for an elevated tank that gravity feeds waterers	3,000 gallon poly tank $1,500; 5,000 gallon tank $3,500 plus site preparation; may be able to use recycled tank

Power Sources, Pumps, Pipelines and Storage Tanks

Solar Power

Overview

Solar pumping systems provide dependable, low-maintenance watering systems in remote locations where other power sources are unreliable or unavailable. The cost of a solar pumping system is usually less than purchasing and installing a windmill. Solar pumping systems can be used for both wells and surface water sources (ponds and streams).

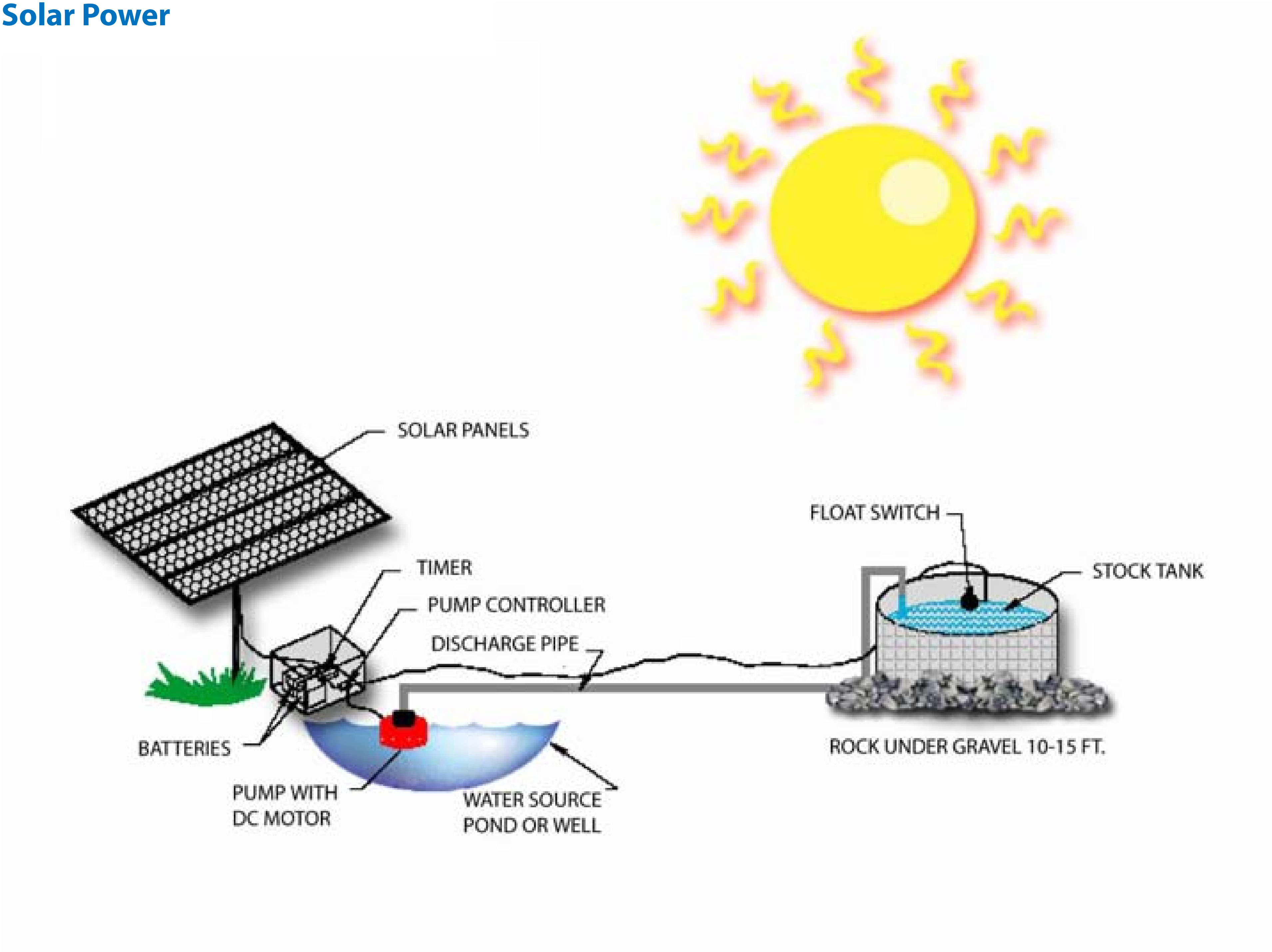
Advantages

- Can efficiently pump water to a higher elevation
- Can be used to pump water to a storage location which can supply multiple outlets
- Allows relocation of the water supply to reduce direct stream and pond access by livestock
- Livestock often prefer to drink from a trough
- Can replace windmills
- Long, useful life
- Low operation costs and minimal maintenance
- Producer can install
- Pump easily replaced and can be repaired

Limitations

- Relatively high initial cost
- Producer will need a voltmeter and know how to use it
- Typically components are only available from specialty supply sources
- Lightning may damage the pump

Solar Power


SOLAR PANELS
TIMER
PUMP CONTROLLER
DISCHARGE PIPE
FLOAT SWITCH
STOCK TANK
BATTERIES
PUMP WITH
DC MOTOR
WATER SOURCE
POND OR WELL
ROCK UNDER GRAVEL 10-15 FT.

Solar Power

Design Considerations

Solar water pumping is the process of pumping water with the use of power generated by sunlight. Solar pumping systems are reliable stand-alone systems that require no fuel and very little attention. Sunshine works well as a power source for livestock watering because the days and times with the greatest solar energy are the days and times that livestock have the greatest water demands.

The five basic parts of a solar watering system are a panel, a sun tracker, a controller, a pump, and a storage cistern or tank.

A ***panel*** converts the solar energy into electrical energy. The size of the panel must match the power needed by the pumps. High lift (deep wells) and high rates of flow increase the power needs.

In general, each installed watt of power will cost about $5.00. As an example, a system to pump 3 gal/minute with 50 feet of head (pressure) uses two 55-watt panels that cost about $250 each. Panels have a long life and many have a 25-year warranty.

A ***sun tracker*** allows the panels to follow the sun, increasing solar panel efficiency. Some systems use passive tracking, which takes no power from the panel electrical system. The sun tracker allows the system to pump an estimated 30-40 percent more water during the summer. One tracker comes with a 10-year warranty.

A ***controller*** converts the variable energy from the solar panel to a constant voltage for the pump. The controller includes a pump speed control circuit, a tank level switch circuit, a low water cut-off circuit (so the pump does not continue to run in a dry well), an electronic circuit breaker and indicator lights. Controllers must be sized for the voltage and amperage needs of the pump.

A ***pump*** does the actual pumping of the water using the direct current produced by the panel. Many are diaphragm pumps that work on a positive displacement process. These have the capacity to pump water to greater height (higher head) with more power but without much decrease in volume.

A ***storage cistern or tank*** is optional but has several advantages. They are less expensive, more trouble-free and more efficient than storing power in batteries for pumping during cloudy weather. Since water is always a critical issue, the tank should be able to store a minimum three- to six-day supply of water, or whatever you think your needs may be during cloudy weather or during a system failure.

Back-up batteries may seem like a good idea during periods of cloudy weather, but they have several limitations. Batteries add cost to the system, reduce the efficiency of the overall system, and can become another source of problems and maintenance needs. Storing water instead of power provides better performance and reliability.

Complete component costs (2004) for a system that has the ability to pump 3 gal/min at 50 feet of head were $2,161 and included two panels, a sun tracker, a controller and a direct current pump.

Pump

Overview

Pumps are the most common and least expensive way to lift, move, and pressurize water. They are commonly used to lift water from a well or cistern to a storage tank at a higher elevation or to pressurize the water system to deliver it through a pipeline to the place of use. Pumps are also used to pressurize or move other fluid or semi-fluid materials. This section sheet covers pumps used for water only. It is not intended to provide information about pump use for any other fluid.

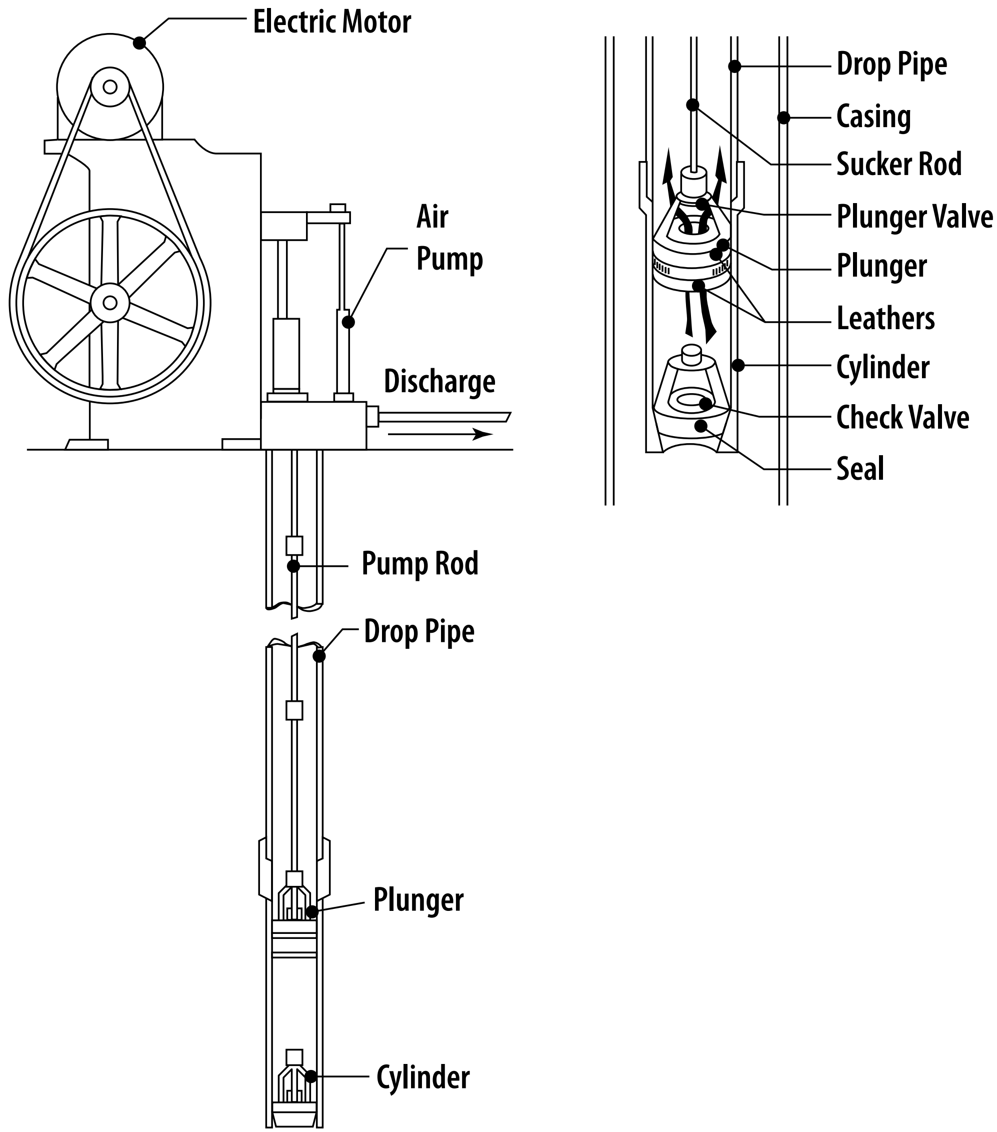
Advantages

- Modest initial cost and a fairly long life
- Pumps used for clean water require little maintenance except piston or reciprocating pumps
- Simple and easy for the user to understand
- User typically can replace a small pump at the surface with available tools
- Easily powered by an electric motor but can also be engine-powered.
- Available in wide size range from several manufacturers
- Electrically powered pumps are easy to automate even from a remote site

Limitations

- Should be selected for the intended application (flow and pressure)
- A pump not matched to its application may be inefficient or may not work at all
- Engine-powered pumps must be checked daily
- Controller specific to the application is used to operate an electric-powered pump
- A pump in a well requires pulling the pipe and pump for service; may require special equipment

Reciprocating or Piston Pump



Pump

Design Considerations

Pumps are used to lift water and add pressure for the intended use. The two broad classes of water pumps include centrifugal (or turbine) and positive displacement. Each type has specific properties which make it best suited for a specific set of conditions. The following descriptions summarize properties of the most common pumps used for water.

Centrifugal pump: This pump has a large impeller, so use in most wells is not practical. Centrifugal pumps are commonly used to move or pressurize both clean water and wastewater. If the well is shallow (less than 24 feet to water), a centrifugal pump may be used at the surface. Designs that produce high heads are readily available. This pump is simple, operates smoothly, is very efficient, and has a long life. When the pump location requires a suction line to lift water to the intake, a check valve is essential to keep the intake line full of water and avoid priming it with each use.

Diaphragm pump: This positive displacement pump is quite simple in design. An off-center knob or cam on the drive shaft moves the diaphragm back and forth and produces a pulsating discharge. A check valve on the intake side allows water to enter but not flow back and a second check valve on the outlet side allows water to exit but not reenter the cavity. This pump is often used for solar powered water systems.

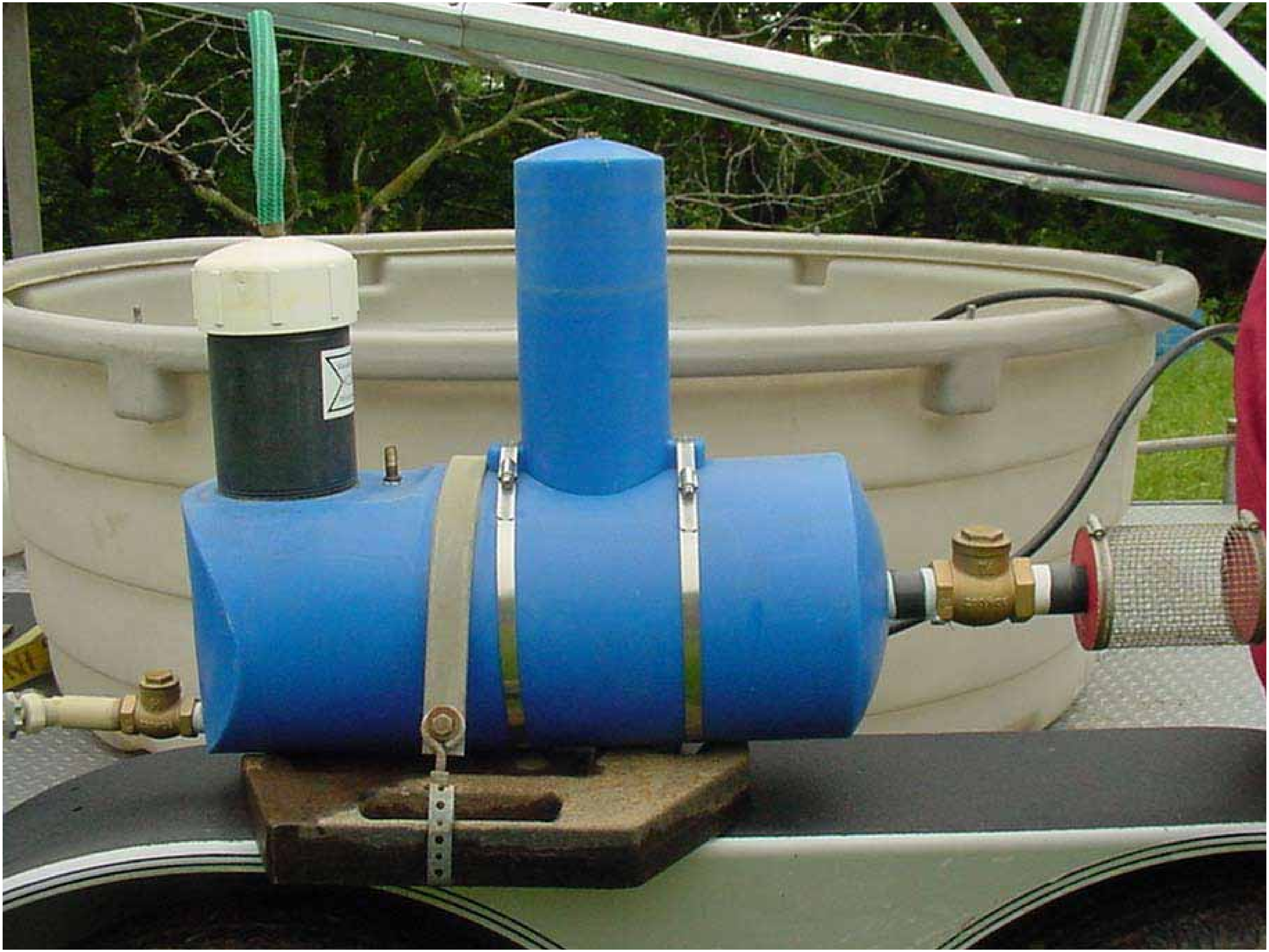
Jet and deep well jet pump: This pump has historically been the most common for shallow wells especially sand point wells with water depths up to about 25 feet. It normally consists of a centrifugal pump and a jet assembly to create a low pressure zone that lifts water from the well. When the jet is placed down in the well, the pump can be used for higher lifts approaching 100 feet. The higher the lift to the pump intake the more water is required through the jet, which means less water is available for discharge. This pump is not as efficient as other types, but usually this is not a big concern for intermittent use of livestock water. A major advantage is that all moving parts of the system are at the surface and are easily accessible. However, this also means that they will freeze, so a pump house is the preferred means of protection.

Piston or reciprocating pump: This is the most common pump used for windmills and operates similarly to the diaphragm pump. A piston or plunger moves up and down and check valves are used on the intake and plunger. This type of pump has a pulsating discharge. It is easily adapted to hand or powered operation. A disadvantage of this pump is wear and maintenance of the moving parts. Though commonly used for most farmsteads prior to electricity, it has now been replaced by other types that have continuous flow and are better suited to electrical power. In remote locations, such as pastures where electricity is not available, this pump is still used, typically powered by a mechanical windmill. This pump can be used for very high lifts.

Submersible turbine pump: This pump is the most common in use today for small water wells. The pump has small impellers to easily fit inside the well casing so each impeller has limited pressure capacity. This is overcome by using multiple stages (impellers) in series on a common shaft to develop the head required. This type of pump is efficient, has a low operating cost, and has a long life. Designs are available for a very

wide range of flow and pressure conditions. The motor is at the bottom, the impellers and discharge at the top, and the intake is between the motor and the impellers. Waterproof wires deliver electricity to power the motor.

Maintenance of pumps: All pumps are like other mechanical devices and eventually need maintenance, repair, or replacement. All except the jet pump require pulling the pump out of the well to replace it or to do maintenance. This is labor intensive and may require well driller's equipment.



Wind-Powered Air Pressure System

Overview

This type of windmill converts wind energy into air pressure using an air pump. Compressed air can be conveyed easily to the point of use to power an air-lift pump, pond aerator or other device.

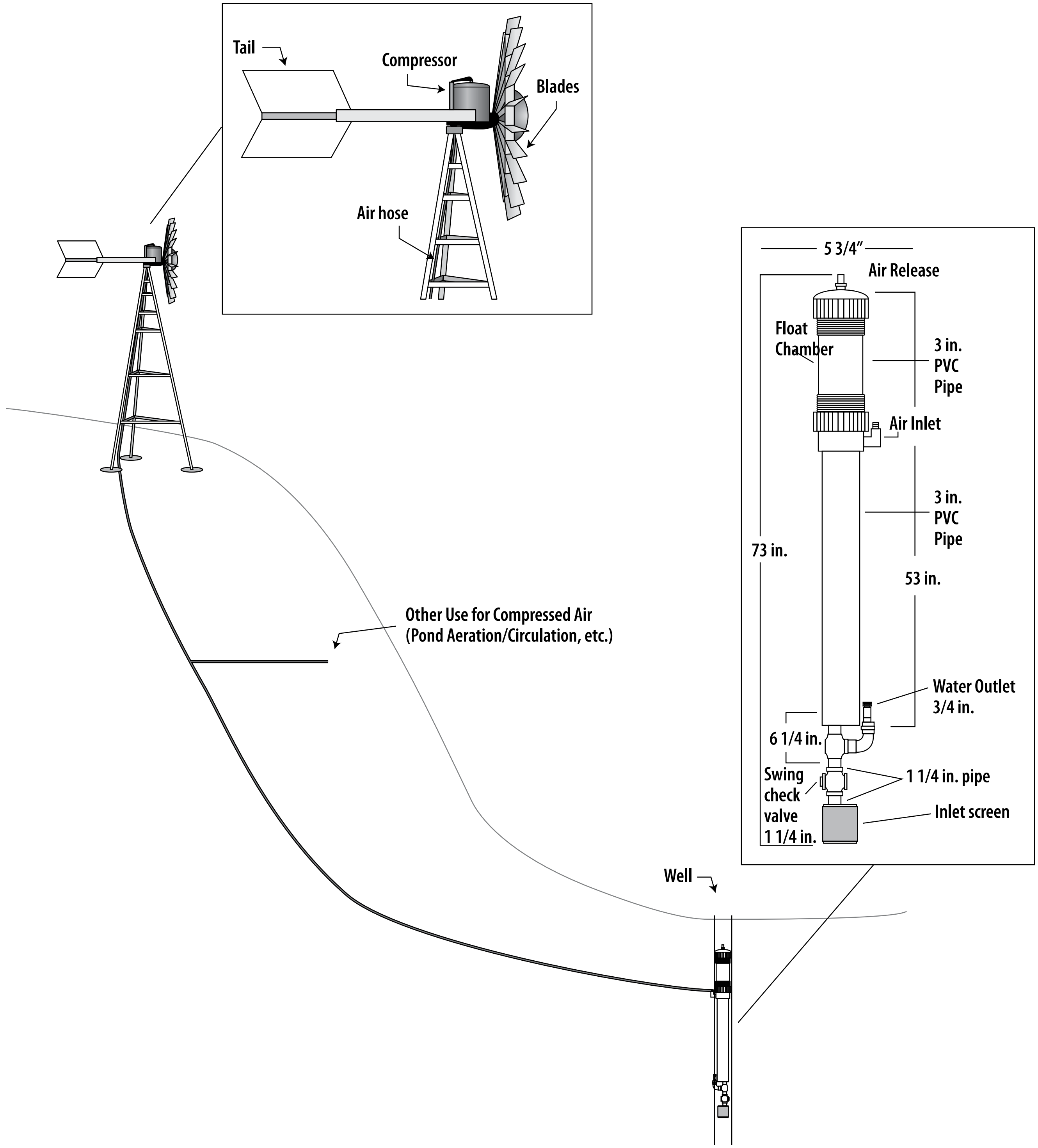
A traditional windmill converts wind energy to mechanical power to operate a traditional cylinder pump. A windmill air-lift pump converts wind energy to air pressure, which then powers a very simple pump. Windmill air-lift pumps are a very simple way to convert wind energy into a form that can be used to pump water.

Advantages

- The technology is simple and easy to understand, use, and maintain
- Can be located at an optimal site for wind conditions up to a quarter-mile from the air-lift pump
- Compressed air can easily be piped to the pump
- The windmill rotor wheel and air pump are relatively trouble-free pieces of equipment
- System components are moderate in cost, have a long life, and require little maintenance
- Compressed air can be used to pump water, aerate a pond, circulate water in a pond, and other uses
- Wind velocities are usually stronger during the daytime hours, closely matching livestock water needs

Limitations

- Pump intake must be placed deep into the well or water source
- Inadequate wind at some sites
- Intermittent winds may mean a large storage tank is needed for adequate water supply during still days or when wind is inadequate to power the pump
- An air-lift pump requires higher air pressure to achieve greater lifts
- Few sources of components; mostly provided by small companies which may change ownership or go out of business


Tail
Compressor
Blades
Air hose
Other Use for Compressed Air
(Pond Aeration/Circulation, etc.)
Well
5 3/4″
Air Release
Float
Chamber
3 in.
PVC
Pipe
Air Inlet
3 in.
PVC
Pipe
73 in.
53 in.
Water Outlet
3/4 in.
6 1/4 in.
Swing
check
valve
1 1/4 in.
1 1/4 in. pipe
Inlet screen

Wind-Powered Air Pressure System

Design Considerations

Wind-powered air pumps for pumping water require a rotor, air compressor, air line, and air-lift pump.

Windmill rotor (turbine): A turning shaft is the major component that harnesses the wind energy and immediately converts it to mechanical energy. A horizontal axis drag or drag/lift rotor is the typical type used. The power output of the turning shaft depends on the size of the wheel, the rotor design, and the rotation speed. The rotational speed depends not only on the wind velocity but also on the type of rotor and rotor design. Knowledge of the wind at the site and the power needs is essential to correctly size the rotor.

Air compressor: This component is powered by the rotating shaft directly connected to the windmill rotor. The air pump should efficiently convert the power of the rotating shaft to compressed air. A piston pump is typically used for this application, but diaphragm pumps are also used. The size of the pump depends on the volume and pressure needed for the intended use. The compressor pump must be sized to meet the needs of the air-lift water pump or other uses, as well as to match the power produced by the windmill rotor.

Air line: This component connects the air compressor to the air-lift pump. The pipe can be up to a quarter-mile long, but shorter is better. To avoid excessive friction loss, the pipe size may have to be increased with longer separation distances from the compressor to the air-lift pump.

Air-lift pump: There are different types of air-powered pumps. The simplest type consists of an air tube and the pump tube. The air tube is typically on the outside of the pump tube with an engineered air injector part high in the interior of the pump tube. It has no moving parts, is very simple, and can be used to pump abrasive materials without damaging the pump. The rising air lifts the water and creates the pump action. This pump must be sized for the application, capacity to deliver water, and well depth. The pump tube must extend deep into the water – 70 percent of the lift height for shallow wells and down to 40 percent of the lift height for wells 300 or more feet deep. Neither the pump nor any of the components is damaged by running dry.

Other pump types use a few valves or moving parts to cause the air pressure to displace or force the water out of a chamber. The valve then opens to release the air and allow water to enter. Another type uses plungers to transfer the pressure of the compressed air to the water in alternating sequences.

Windmill

Windmills are an energy-efficient source of power for pumping water. Windmills have been a part of water supply systems in Kansas for more than a century. They are still in common use in the grassland areas of the state.

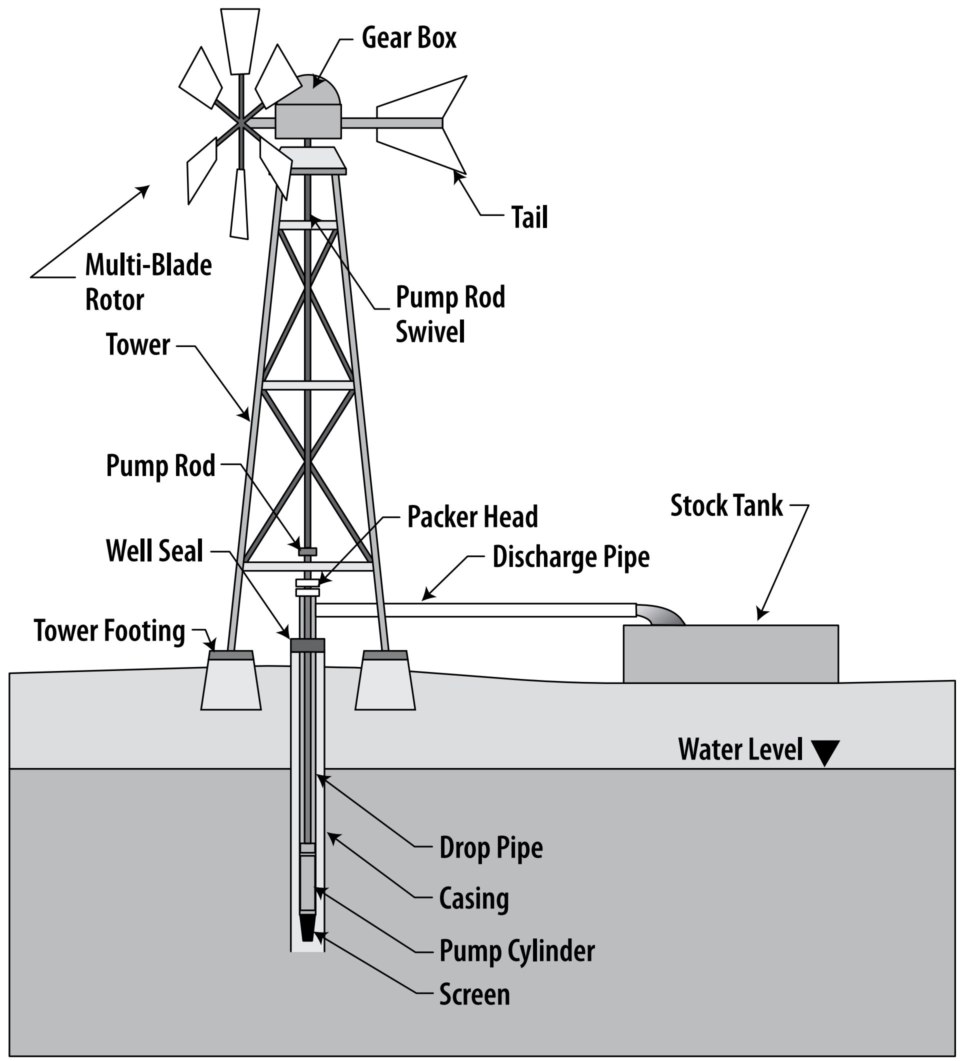
The most important application of windmills in remote areas has been for mechanical power to pump water. These systems were perfected in the United States during the 19th century, beginning with the Halladay windmill in 1854 and continuing to the Aermotor and Dempster designs which are still used today.

Advantages

- Uses an abundant free energy source
- Well suited to sites where electricity is unavailable
- Has a long life (more than 20 years)
- Maintenance requirements are low tech
- Very simple mechanically and easy to repair
- Good choice in Kansas, where wind is a reliable energy source

Limitations

- Dependent on steady source of wind
- May need a large water storage tank in locations with less reliable wind supply
- Windmill heads are a favorite target for small arms fire
- Maintenance must be done while atop the windmill tower
- Need special equipment or contractor to install the windmill head
- High initial cost
- Subject to damage by strong winds associated with severe storms and tornadoes


Gear Box
Tail
Multi-Blade Rotor
Pump Rod Swivel
Tower
Pump Rod
Packer Head
Stock Tank
Well Seal
Discharge Pipe
Tower Footing
Water Level
Drop Pipe
Casing
Pump Cylinder
Screen

Windmill

Design Considerations

The term “windmill” is frequently used to collectively refer to the windmill head and the tower that supports the head. The size of the windmill head should be selected based on the depth of the well and the size of the pump. A 6-foot head will pump water from a 60-foot well at a low rate; an 8-foot head will pump water from an 150-foot well at a low rate or a shallower well with a larger pump at a higher rate. Water can be extracted from depths up to 800 feet with windmills. Deeper wells require larger heads (up to 20 feet in diameter).

The windmill head swivels or rotates to face into the wind. Windmills should be sited at least 75 feet away from trees and buildings, which can alter wind currents, resulting in damage to windmill heads. Trees and buildings also can slow wind, reducing the force available to convert to energy.

In most cases a hoist will be necessary to install a windmill head and it can also be used to raise the tower. The head is awkward to handle because of its size and weight.

A typical cost for a new 6-foot windmill head is about $1,800. A very large head (20-foot) can cost as much as $20,000. A rebuilt 6-foot windmill head costs about $300. Towers can be custom built or purchased new, but in areas where windmills are common, most heads are installed on existing or relocated towers.

Maintenance Considerations

Towers typically have ladders attached to the side and a small platform at the top to facilitate routine maintenance. However, maintenance on a windmill head is dangerous, especially when the wind is blowing which may be much of the time for some locations and seasons. Before you choose a windmill, carefully evaluate the cost of service.

Oil levels in windmill head gearboxes should be checked twice a year and changed when oil becomes dirty. Insufficient oil will result in rapid wear and failure of gears. Fan blades and bolts should be checked at the same time as the oil and replaced as necessary.

When larger repairs are needed, windmills can usually be repaired quickly (within a few hours) by professional service providers so that livestock aren’t stranded without water. Consider where the service provider is located and the cost of travel to the windmill site.

High quality pump leathers should last at least 5 years. Sand in the water greatly increases the wear on the pump and will severely shorten the life of the leathers.

Sources:

American Wind Power Center and Museum, Lubbock, TX (*http://www.windmill.com*)

David Evel Windmill Service, Ransom, Kansas

Animal-Activated Pumping System

Overview

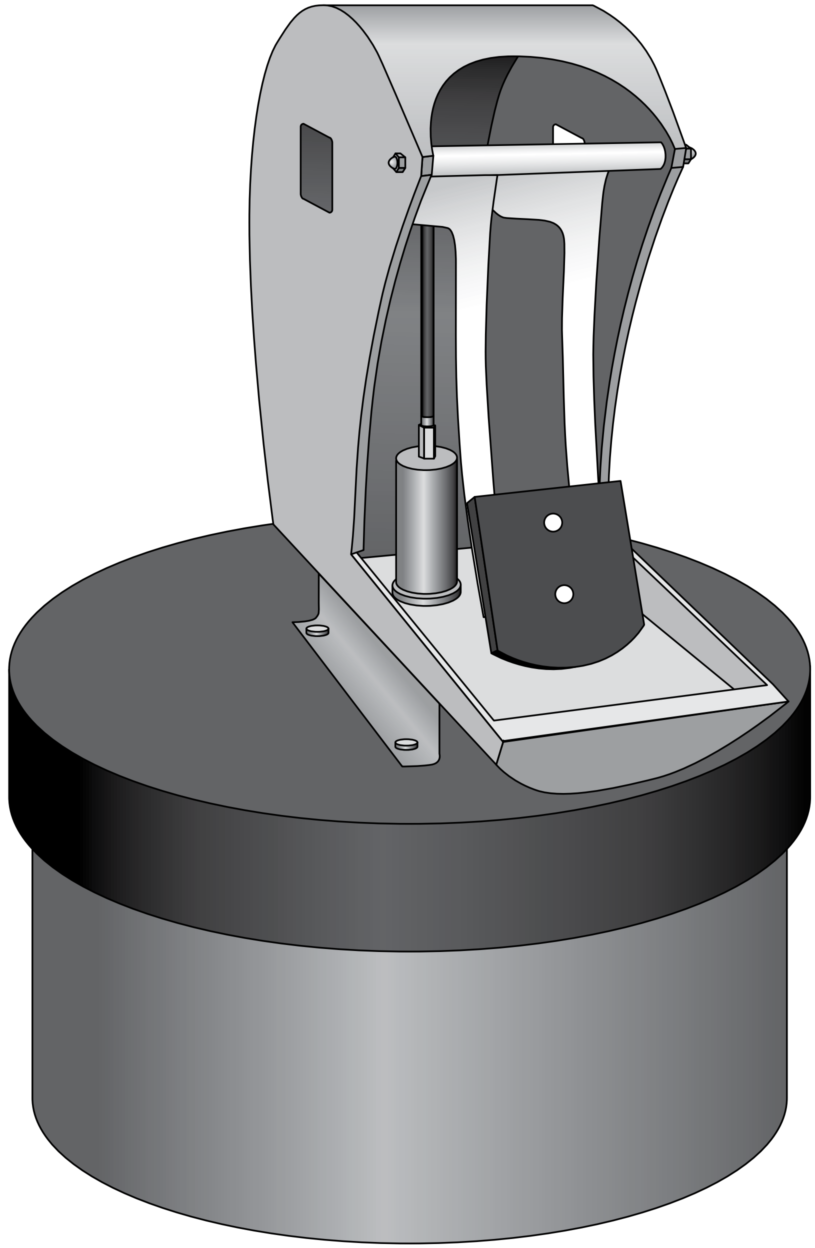
Various devices have been invented that depend on livestock learning to "pump" water from a pond or stream into a drinking bowl or trough. Nose pumps and foot pumps are the most common of animal-powered pumps. While simple and inexpensive, they are best adapted to non-freezing conditions and moving water short distances.

Advantages

- Simple, rugged and portable
- Animal powered; no electricity or solar panels needed
- Adaptable to ponds, streams or shallow wells
- Inexpensive (usually less than $500)
- Livestock learn to use nose pumps quickly

Limitations:

- A unit can only supply up to 25 head
- Small calves cannot operate the pump
- Pump can only draw water about 20 feet vertically or 200 feet horizontally
- Cannot be used in winter as water in drinking trough and pump may freeze



Animal-Activated Pumping System

Design Considerations

Nose pumps are diaphragm pumps that operate as stock push a paddle out of the way to access water in a sloped trough. As the animal withdraws after drinking, the paddle returns and pumps about one pint of water into the trough for the next drink. Water comes through a suction hose with a foot valve mounted in a stream, pond or other water source. Since the process is relatively slow, a limited number of livestock can be supplied in a timely way. Nose pumps are portable and can be pushed about by cattle if not pinned to a solid base, such as railroad ties.

Pumps can only create about 20-25 feet of vertical lift or about 200-250 feet of horizontal draw (or a combination of these). Less lift and distance makes the paddle push easier. This restricts pump use for distributing water away from the source (pond, etc).

Foot pumps operate on the same principles. Stock generally take longer to learn use of the foot pump. Floats may be designed to keep the drinking trough from overflowing.

References:

Bartlett, B. 1996. Watering Systems for Grazing Livestock. Great Lakes Basin Grazing Network and Michigan State Univ. Extension, East Lansing.

Agriculture and Agri-food Canada. 2006. Livestock-powered water pumps. Agric. and Agri-Food Canada, Toronto. *http://www.agr.gc.ca/pfra/water/facts/nosepump.pdf*

Water-Powered Pump

Overview

The traditional water-powered pump is a ram pump. It uses the energy of flowing water to lift a smaller amount of water to a higher elevation than the source. When flowing water is suddenly stopped it creates a high pressure or shock wave (water hammer) that pressurizes a portion of the water. Because no electric or mechanical power is required, it is very different from other pumps used for water. A ram has only 2 moving parts so there is little to wear out or fail. The flow required depends on the amount of water to be pumped and the ratio of the fall to the lift heights. For more than 100 years rams were major movers of water for homes, farms, railroads, towns, and industry.

A sling pump uses a flowing stream to turn many coils of pipe with intervals of water and air to develop the pressure to lift water as high as 80 feet. This pump is a fairly recent invention. Like a ram pump, it requires no power, has a relatively low cost, and has a long life.

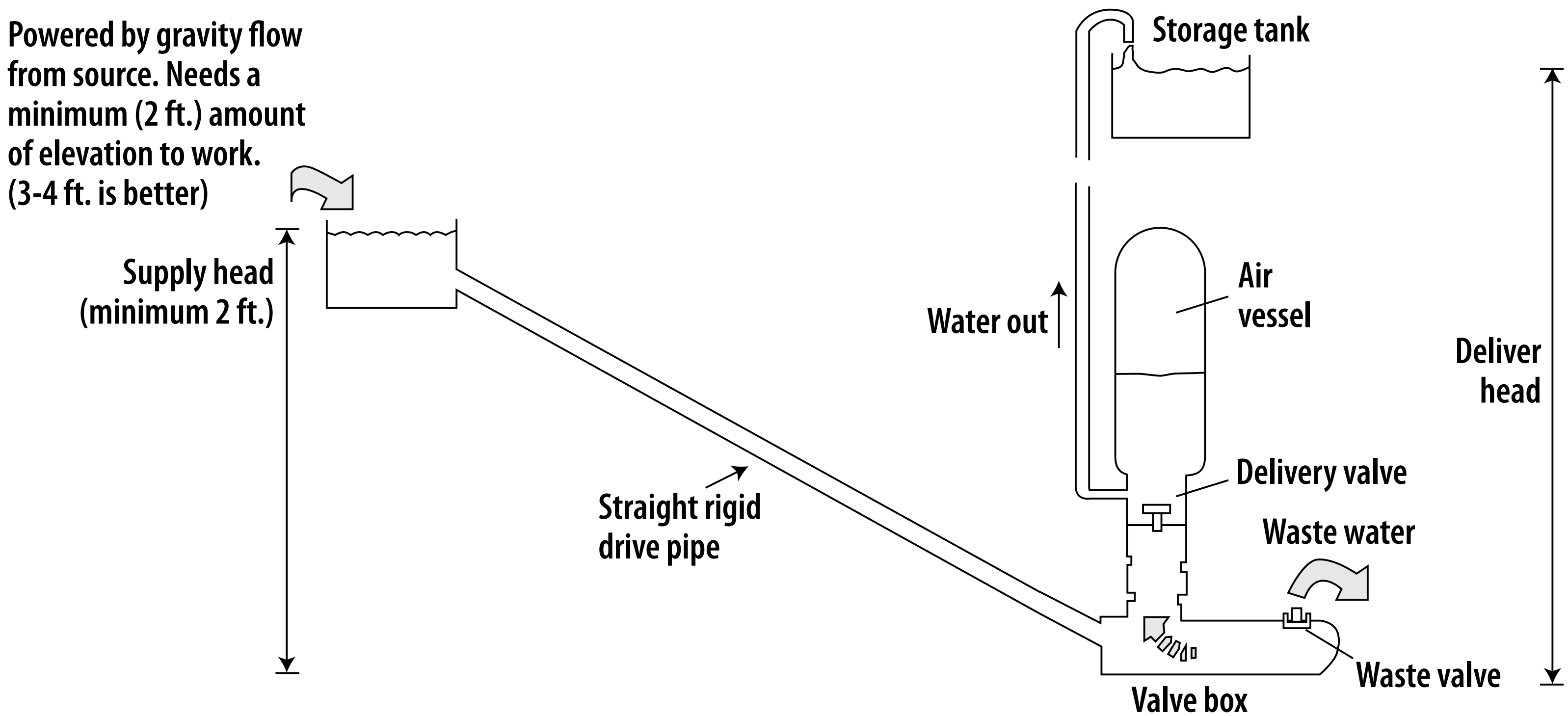
Advantages

- Relatively economical to purchase and to install
- Proven designs are commercially available in a range of sizes for small systems
- Ram pumps can be home built using plumbing parts with available plans
- Will give many years of service when properly installed and maintained
- No input energy required
- Relatively trouble-free operation
- Well suited to remote locations with no power
- Long delivery lines and high lifts can be achieved with the correct conditions

Limitations

- Requires a year-round surface flow to power the pump
- Winter operation is difficult except under special conditions

Ram Pump


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

Water-Powered Pump

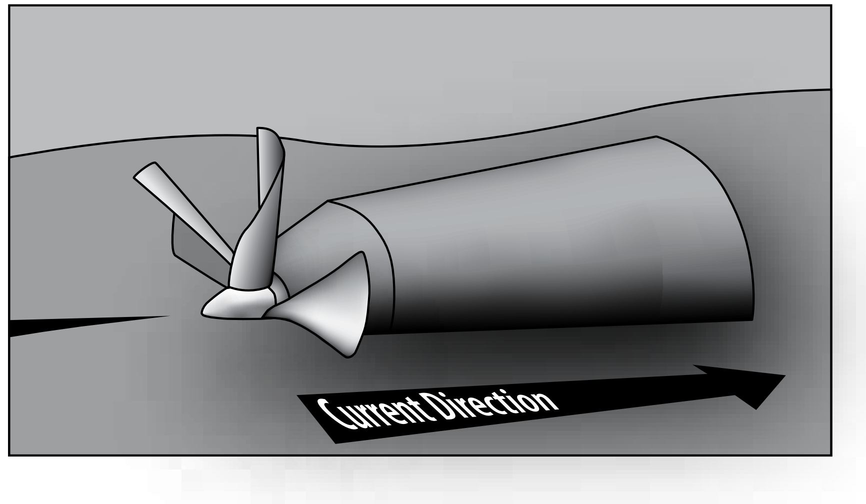
Ram Pump Limitations

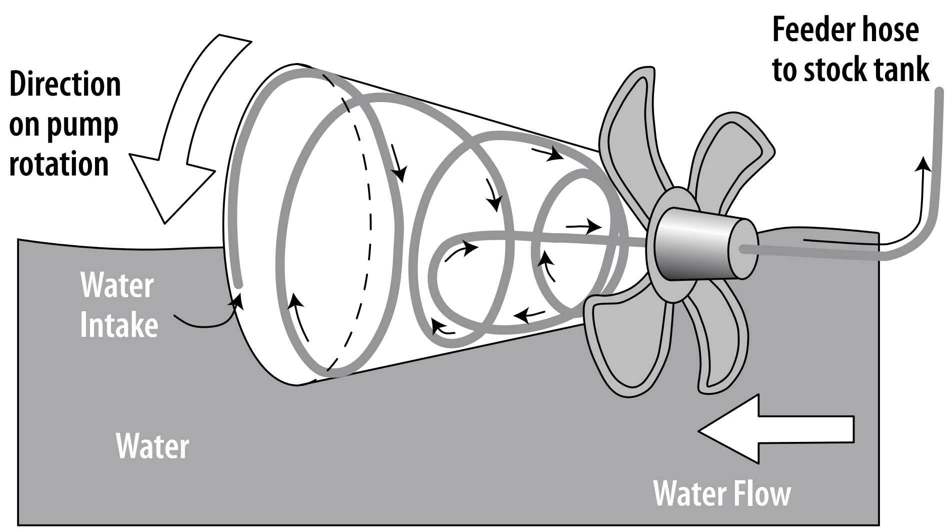
- The fall from the source to the ram must be at least 2 feet
- Requires several times as much pass-through water flow for high lift-to-fall ratios; high lifts require high falls
- Source water should be free of debris and sand
- Suitable sites include streams with a steep gradient, waterfalls, or springs above streams
- Winter operation requires an insulated structure and a heat source, such as passive solar heating

Sling Pump Limitations

- Requires a 2.5-foot minimum depth of flowing water and a velocity of at least 1.5 feet per second
- Cannot be used when water freezes
- Must be anchored in a flowing stream, leaving it subject to damage and even loss in high flow or flood conditions

Sling Pump


Current Direction


Feeder hose
to stock tank
Direction
on pump
rotation
Water
Intake
Water
Water Flow

Water-Powered Pump

Design Considerations for a Ram Pump

Essential components of a ram pump system include a consistent water source, a drive pipe, a ram pump and a delivery pipe.

Consistent water source: The source must be at least 2 feet (higher is better) above a suitable ram site with good discharge location. The source could be a stream with a steep gradient where a small dam or diversion channel can be constructed, or – better still – a spring above the stream channel. A hillside spring that flows at a reasonably constant rate (or a minimum rate to drive the pump) is ideal. If a dam is used, the intake for the drive pipe may extend through the dam. Most small ponds would not store adequate water to drive the pump as needed during dry periods. However, a spring-fed pond may work fine.

Drive pipe: A drive pipe of rigid, preferably straight pipe (usually galvanized steel) delivers the water to power the ram. The length of the pipe should be in the range of 150 times the diameter of the pipe to no more than 1,000 times the diameter of the pipe. The drive pipe usually has a ball valve adjacent to the connection with the ram pump. A stand pipe can be added to avoid a long drive-pipe length.

Ram pump: The ram pump consists of an impulse valve similar to a check valve, a spring loaded check valve, an air chamber, tees, couplings, and a pressure gauge.

Delivery pipe: A delivery pipe connects the pump to the place of storage or use. A ball valve adjacent to the union that connects to the ram pump allows the line to be shut off so the pump can be removed for service or repairs. Because this line has less water flow, it is smaller in diameter than the drive pipe. It does not have the shock waves that the drive pipe does so a plastic pipe will perform well for this line. It is important to minimize friction loss to maximize the amount of water delivered. Avoid as many fittings and bends as possible and use a larger diameter pipe to minimize friction loss.

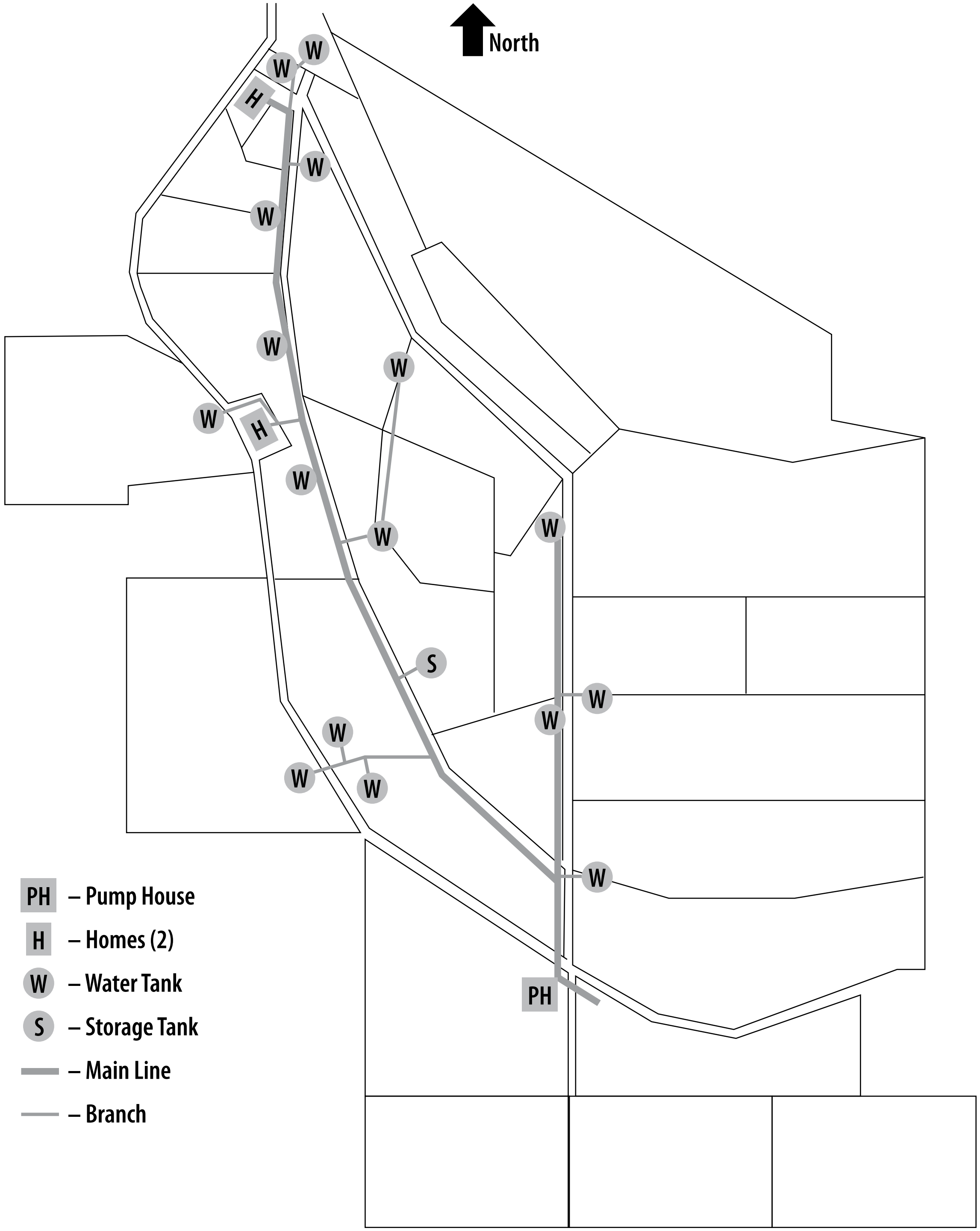
Design Considerations for a Sling Pump

Essential components of a sling pump system include anchoring, a propellor to turn the pump, and a delivery hose.

Anchoring: This secures the sling pump in an adequate depth of flowing water. This may require stakes and cables.

Propeller: A propeller to turn the pump. The pump contains a coil of pipe and has an intake so alternating air and water enters the coils as the pump turns. The water lubricated swivel connection, its only moving part, delivers the water from the pump to the delivery hose.

Delivery hose: This connects the delivery pipeline to the place of use.


North
W
W
H
W
W
W
W
W
H
W
W
W
S
W
W
W
W
W
W
PH
PH – Pump House
H – Homes (2)
W – Water Tank
S – Storage Tank
– Main Line
– Branch

Pipeline Network from Offsite Water Source

Overview

When several water outlets are close together, as for a feedlot or rotational grazing system, it usually is less expensive to install a pipeline network than to install a separate water source, pump, and energy supply for each outlet. The pipeline is sized to carry the amount of water required by the length of line, the difference in elevation, and water demand at each outlet. Pipeline sizes and features must be planned for each specific system based on the site and system requirements.

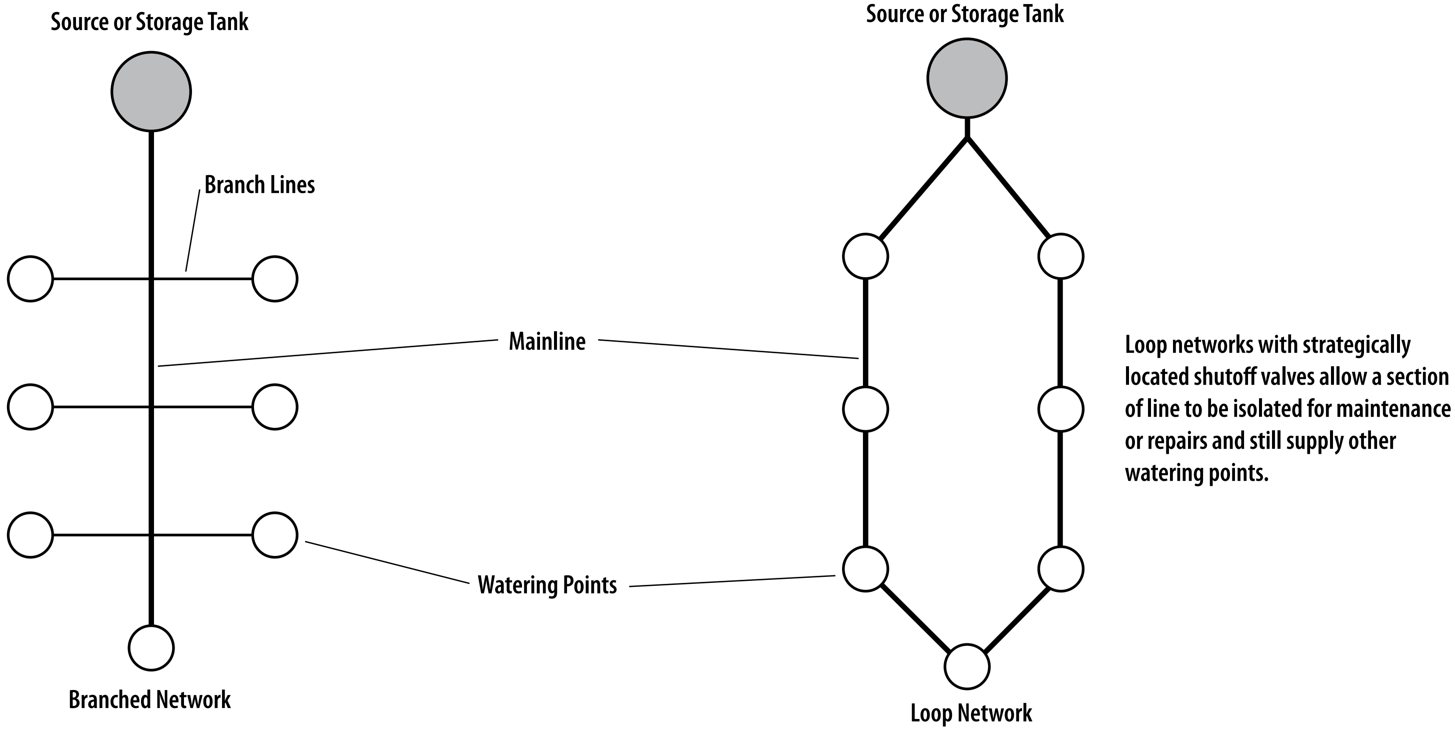
Advantages

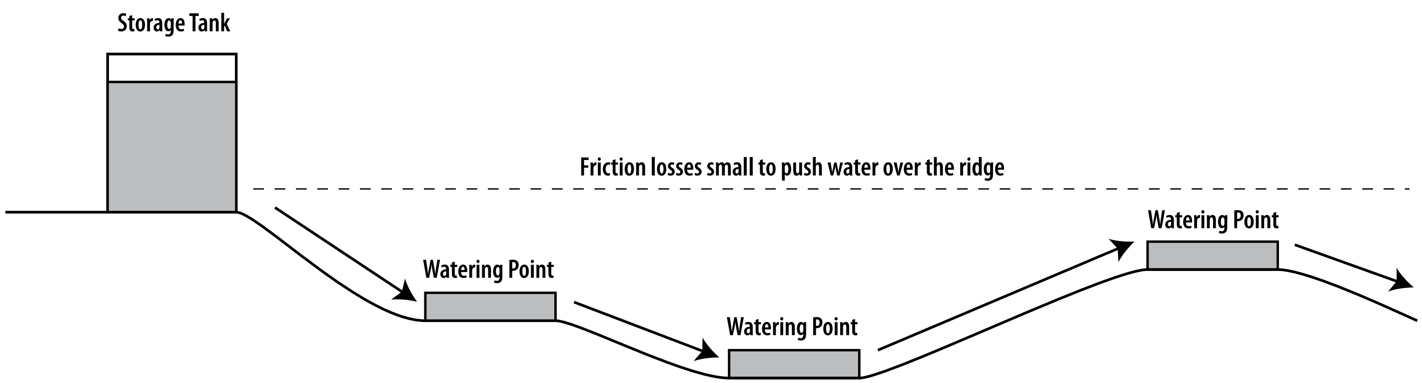
- Typically requires only one adequate water source and an appropriate pump to supply several outlets
- For very large systems, a few water sources could be connected for improved performance or increased reliability
- A single large capacity source is often less expensive and more reliable than several smaller ones
- Less maintenance is usually required for one source and pump than for several
- Especially well-suited if water or power is not readily available for all waterer locations
- In remote areas pipeline is often less expensive than developing multiple water sources and power supplies

Limitations

- Redundancy or backup for pumps and power may be important because there is a single source for multiple waterers
- The more outlets supplied by the network, the greater the source yield required
- Shallow rock may substantially increase the cost of installation and limit the depth that water lines can be buried
- Water lines must be installed below frost level to avoid winter freezing
- System design and construction may require an experienced hydraulics professional
- Pipe network design is site-specific for local conditions and needs, such as topography and pasture arrangement

Types of Water Distribution Networks





Pipeline Network from Offsite Water Source

Design Considerations

Designing a large livestock-water delivery system is similar to designing the water network for a small town or rural water district. The assistance of a qualified engineer is usually required to determine water line size and valve locations to assure adequate capacity for delivering the required amount of water. The designer should locate air relief valves, vacuum relief valves, shutoff valves, water storage, and thrust blocking as well as pipeline and fittings.

Air relief valve. This valve allows air that accumulates at high points of the water line to be released so it does not restrict water flow. In some cases when the water line velocity is high enough to force the air through the line the air can be released at a water delivery point.

Vacuum relief valve. When there are large differences in elevation, this valve is important to prevent vacuum in the line, which can result in the collapse or breakage of the pipe. The valve is typically used with the air relief valve to minimize the number of fittings and reduce cost.

Shutoff valve. The pipeline network design should consider shutoff valve locations that allow sections of the line to be isolated for repairs and maintenance. This consideration should include an evaluation of valve location and cost relative to the advantage of having the water system remain functional during repair or service. A looped pipe network enables most of the water system to remain pressurized and thus usable while a portion of it is isolated and depressurized.

Online storage. Public systems include storage to hold a temporary water supply to meet instantaneous demands. In livestock water systems, this can be done by using elevated storage tanks (as in public systems) or more typically by using large diameter tanks to provide storage and allow several animals to drink at once.

Pipeline size and specification. Each segment of the water system pipeline must be designed so that the required amount of water is delivered to the outlet. Pressure losses attributable to the diameter and length of a segment must be considered when selecting water system components. Selecting the pipeline specification requires consideration of the operating pressure, pressure surges, and the strength of the pipe. It often is cost-effective to choose a heavier-walled pipe than pressure requires in order to add durability, lengthen service, and reduce repair cost. Fittings must be at least as strong as the pipeline.

Water Storage Tank

Overview

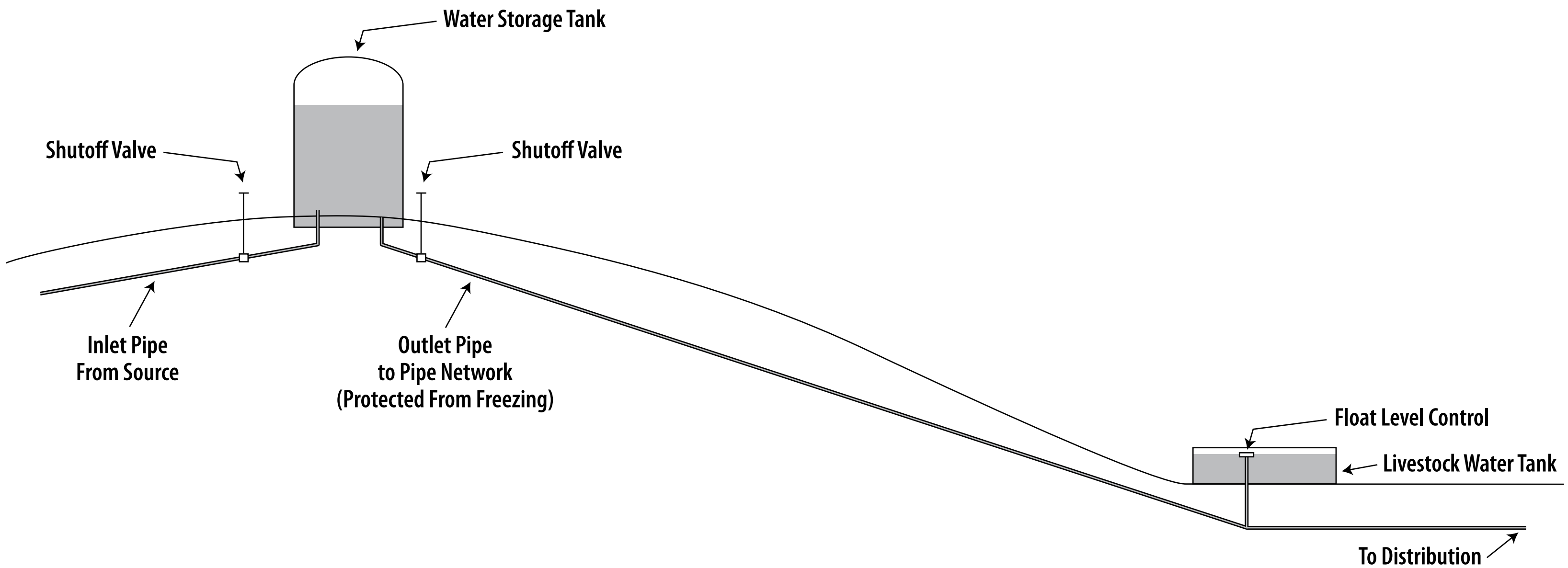
When elevated, water storage tanks provide a reservoir for circumstances when water may not be immediately available from the water source. Such circumstances would include still days in a windmill system, pump failure, or power outage. A storage tank also allows a low-volume but steady water supply to accumulate in quantities sufficient to meet the needs of a herd with heavy water usage during short time intervals.

Advantages

- Several waterers can be supplied from one storage tank
- May need less pipeline than running a separate line from the water source to each waterer
- Can rapidly refill waterer at peak demand times
- Provides backup source of water for intermittent power sources such as solar and wind
- Well suited to a system that has a steady, low flow that is adequate to meet daily demand but not adequate to meet peak flow requirements.
- Very reliable and requires little maintenance

Limitations

- Terrain may be unsuited for an elevated tank that gravity-feeds waterers
- Malfunctioning floats in cattle waterer can cause quick drainage of entire water storage
- During winter, continuous use is typically required to keep tank from freezing
- Tank must be achored or continuously contain water as weight to prevent wind moving and damaging the tank


Water Storage Tank
Shutoff Valve
Shutoff Valve
Inlet Pipe
From Source
Outlet Pipe
to Pipe Network
(Protected From Freezing)
Float Level Control
Livestock Water Tank
To Distribution

Water Storage Tank

Design Considerations

Water storage tanks must be designed for the elevation difference and pipeline losses to meet the water delivery requirement. Water storage tanks enhance intermittent water supplies from windmills, solar powered pumps and sites with low water recharge. To avoid a restriction in flow, the tank entrance should be the same size as the lines entering and exiting. Assistance from a hydraulics expert is advisable to size the tank and water lines for best performance.

The size of the water storage tank is a function of two important factors:

- the amount of water needed – normally determined by the gallons of water per head per day
- the amount of water that can be delivered – normally determined by the average groundwater flow available per month.

Tanks can be made of steel, galvanized steel, fiberglass, or plastic. 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. Coatings can be used to improve the durability of steel tanks. Recycled stainless steel milk tanks can also be used but are likely to be more expensive.

Water storage tanks should be fitted with a float valve that shuts off the water when the tank is full. The tank should have a drain on the downhill side. Valves should be installed to isolate the tank from the pipeline so the tank can be drained for service or repair and the pipeline can still function. Check valves should be installed to avoid undesired flow reversal.

Maintenance is minimal. If the water source is turbid, sediment will accumulate in the tank and should be periodically removed to avoid tank deterioration and water taste and odor problems.

Most water storage tanks gravity-feed to waterers. The water service line should be buried at an adequate depth to prevent freezing and should also have a check valve installed to prevent siphoning of water from the water tank.

Animal Drink Delivery Comparison Chart

Item	Primary Advantages	Primary Disadvantages	Estimated Cost
Concrete waterer	Long useful life; low operation costs	Tanks are heavy; not available at most farm supply stores; shipping costs may be high	About $350, not including shipping or installation
Limited access watering point	Simple and inexpensive; reduced bank erosion; less sediment and fewer nutrients entering streams	Few options for location of watering point	$200 or more depending on size and site conditions
Hardened surface access and rock channel crossing	Easily adapted to various stream sizes and locations; quick installation; long useful life; low maintenance	Relatively expensive; must have suitable site and stream characteristics	About $2,000-$7,000 for materials and installation
Super insulated waterer	No need for supplemental heat to prevent freeze-up	Can be damaged if allowed to freeze repeatedly, especially when not in use	About $500, not including freight and installation
Bottomless tank	Large capacity at comparatively low cost compared with other tanks; serves as water storage as well as drinking device	Permanantly located; can't be moved as can galvanized or fiberglass tanks	Concrete (30' x 30' x 6" pad) $1400; rebar, bolts, overflow pipe $300; rings $1,700
Tire tank	Simple and inexpensive; durable and non-breaking	Removal of part or all of one sidewall to make the tank is difficult; tire size may limit water storage for larger herds	Tire can be obtained free in some cases. Cement for bottom about $25; plumbing (values and fittings) $120-$150; water pipe $0.40/ft.; drain pipe $1.10/ft.; sand and gravel surround $100
Fiberglass or galvanized tank	Because of stored water the larger the tank, the smaller the water delivery capacity needed to supply the animals; can be easily moved as needed	Galvanized steel and fiberglass tanks don't last as long as concrete; empty tanks will blow in the wind	10' diameter galvanized tank $500; 300 gal. fiberglass tank $180

Animal Drink Delivery

Concrete Waterers

Overview

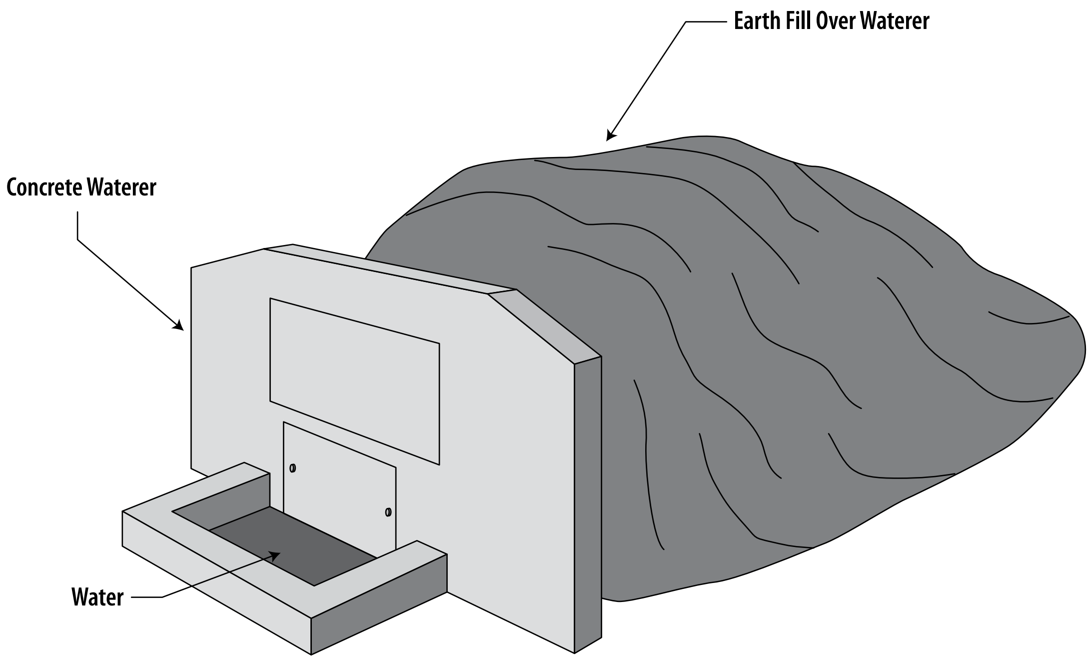
Concrete waterers provide reliable, durable watering sources. They can be installed as gravity-flow systems, eliminating the need for a power source. The area around the waterer can be easily protected with a geotextile and gravel surface. Fence-line installations allow watering two grazing areas with one waterer.

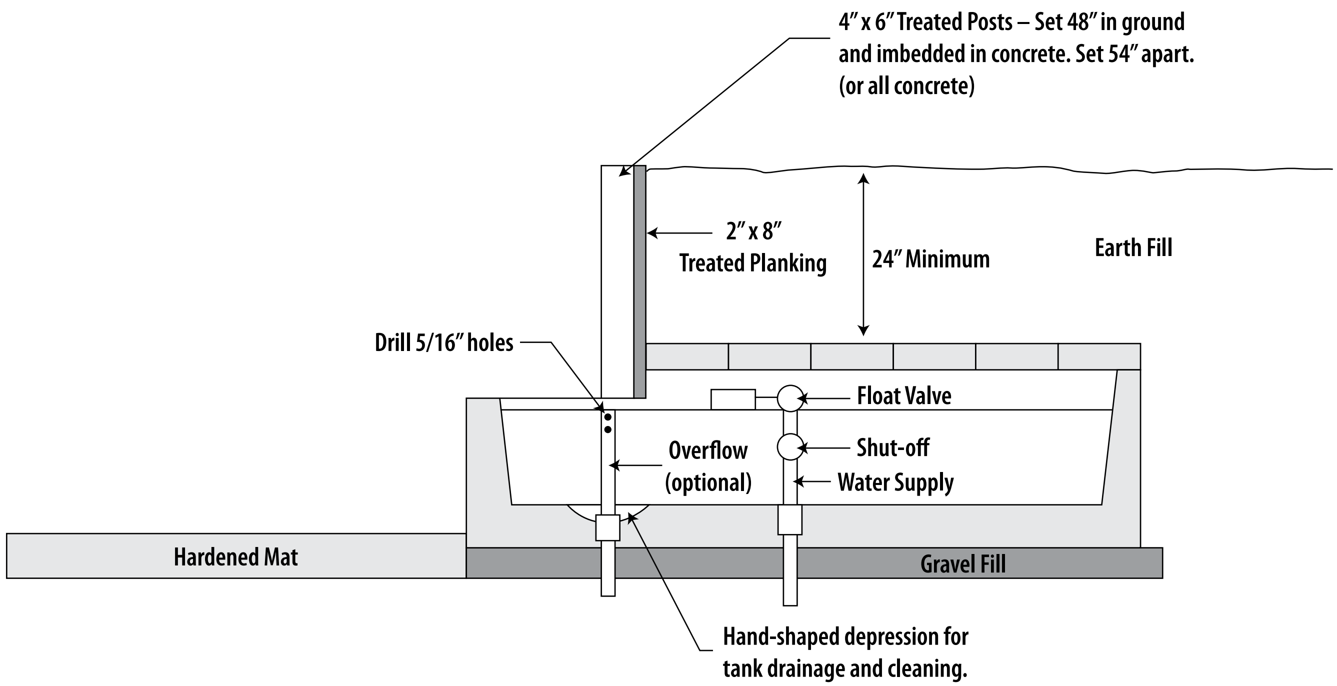
Advantages

- Allows relocation of the water source to reduce or eliminate direct stream and pond access by livestock
- Livestock often prefer to drink from a trough
- Long useful life
- Can be installed to be freeze resistant
- Does not require high water pressure
- Low operation costs
- Used in conjunction with fencing of pond, improves pond water quality and life of pond
- Minimal maintenance requirements
- Producer can install
- Multiple concrete waterers can be plumbed into a waterline if the grade is sufficiently steep
- Can be used with non-pressurized (gravity flow) and pressurized water sources with equal success
- Does not require a poured concrete pad
- Many tank models to choose from

Limitations

- Tanks are heavy, weighing between 2,300 and 3,000 pounds each
- Shipping costs may be high
- Not available at most farm supply stores
- If a pond is the water source, it must have a livestock water pipeline under, through or around the pond dam


Earth Fill Over Waterer
Concrete Waterer
Water


4″ x 6″ Treated Posts – Set 48″ in ground and imbedded in concrete. Set 54″ apart. (or all concrete)
2″ x 8″ Treated Planking
24″ Minimum
Earth Fill
Drill 5/16″ holes
Float Valve
Shut-off
Overflow (optional)
Water Supply
Hardened Mat
Gravel Fill
Hand-shaped depression for tank drainage and cleaning.

Concrete Waterer

Design Considerations

The waterer should be placed on a well-drained gravel or sand site that offers some protection from the wind if the waterer will be used during the winter. The site should include an area of about 15 feet square in front of the waterer for cattle to stand. This pad area can be covered with geotextile cloth and gravel of 1-2 inches in diameter.

The waterer should be located at least 4 feet below the water level in the pond and beneath the dam for positive gravity flow. The pipeline should be buried below the frost line. After waterer installation, dirt will need to be piled around the back and sides to prevent freezing.

The pipeline can be placed either under the dam (new pond construction), or through the dam or out the side of the pond (existing ponds). Usually the trench is constructed from the waterer back towards the pond, stopping about 2 feet from the pond edge. The pipe is laid in the trench, starting at the valve at the waterer end. It is very important to seal the space around the pipeline within 20 feet of the edge of the pond using an anti-seep collar or bentonite clay.

The rest of the trench can be excavated into the pond, going deeper as necessary. The trench must extend far enough into the pond to place the pipe inlet where the water is deepest.

Installation instructions can be obtained by contacting your watershed specialist or viewing tand by viewing "Adopt a Drop: We Can't All Be Up a Creek" (*http://www.oznet.k-state.edu/kcare/KELP%20Water/KELPwaterer_files/frame.htm*). A description of installation is given in the K-State Research and Extension publication *Alternative Livestock Watering: Covered Concrete Water, MF-2737*, July 2006.

Limited Access Watering Points

Overview

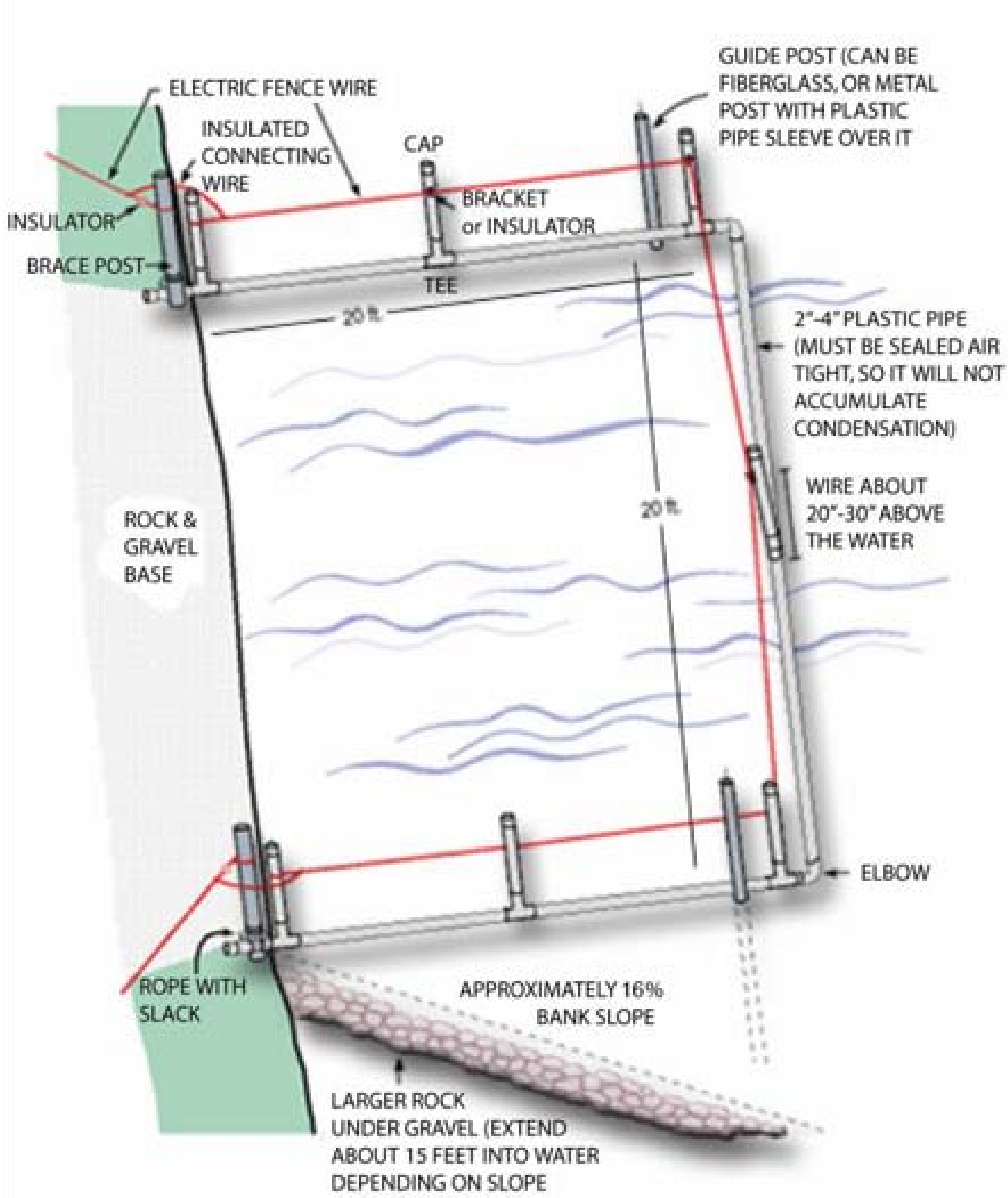
Ponds and streams are common sources of livestock water in Kansas. However, allowing unlimited access can cause severe bank erosion, poor water quality and other related problems. Cattle prefer clean water and avoid steep, muddy approaches to water sources whenever possible. Developing access watering points with a hardened surface and fencing is often fairly simple and solves many of these concerns.

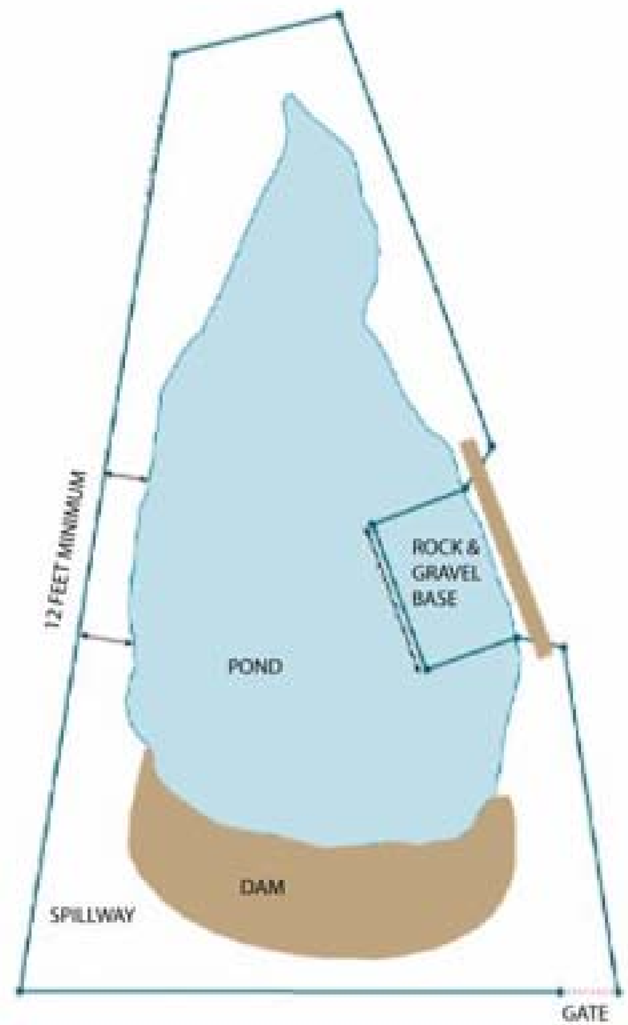
Advantages

- Simple and inexpensive
- Improved livestock safety and health, less foot rot and fewer leg injuries
- Reduced bank erosion
- Less sediment and fewer nutrients entering streams and ponds
- Extended pond life
- Applicable to new and existing ponds
- Increased water intake may mean better livestock gains

Limitations

- Not adapted to large streams
- Fence maintenance required when stream floods
- Few options for location of watering point
- Few examples in Kansas


ELECTRIC FENCE WIRE
INSULATED CONNECTING WIRE
INSULATOR
BRACE POST
CAP
BRACKET or INSULATOR
TEE
GUIDE POST (CAN BE FIBERGLASS, OR METAL POST WITH PLASTIC PIPE SLEEVE OVER IT
20 ft.
2"-4" PLASTIC PIPE (MUST BE SEALED AIR TIGHT, SO IT WILL NOT ACCUMULATE CONDENSATION)
WIRE ABOUT 20"-30" ABOVE THE WATER
ROCK & GRAVEL BASE
20 ft.
ELBOW
ROPE WITH SLACK
APPROXIMATELY 16% BANK SLOPE
LARGER ROCK UNDER GRAVEL (EXTEND ABOUT 15 FEET INTO WATER DEPENDING ON SLOPE


12 FEET MINIMUM
ROCK & GRAVEL BASE
POND
DAM
SPILLWAY
GATE

Limited Access Watering Points

Design Considerations

To encourage animal use, an access ramp or walkway should have a maximum slope of 6:1 run to rise (17%) or a 10 degree slope. Ramps as steep as 4:1 have been used. However, a flatter slope (8:1 to 20:1) is generally better when space allows, especially when conditions are icy. The ramp surface should be compacted and non-slip (crushed rock, gravel or concrete). A 3:1 slope (or flatter) for the sides of the ramp is preferable when site conditions permit.

Width may vary (recommendations range from 4 to 80 feet) but a good guideline is 10 feet plus one foot for each 10 head of cattle – for example, 55 feet for 50 head. Fencing is generally desirable to exclude livestock from other parts of the pond or stream, especially if they congregate and loaf during hot days.

A floating fence made of PVC pipe can be used to restrict acess to the pond reservoir at a cost of $200-300. A 16-foot stream crossing/access point for small streams, using gravel with geotextile and sand base, can be constructed for less than $500.

This practice may require permits. Please read the permit section of this handbook (p. 143).

References

Porter, M.D. and J.S. McNeill. 2006. Livestock water access point in pond fence. The Samuel Roberts Noble Foundation, Ardmore, OK. *http://www.noble.org/Ag/Livestock/Waterpoint/Porter_PondAccess.htm*

Natural Resources Conservation Service. 2003. Conservation practice standard: access road. Code 560. USDA. *ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/560.pdf*

Natural Resources Conservation Service. 2003. Conservation practice standard: heavy use area protection. Code 561. USDA. *ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/561.pdf*

Hardened Surface Access

Overview

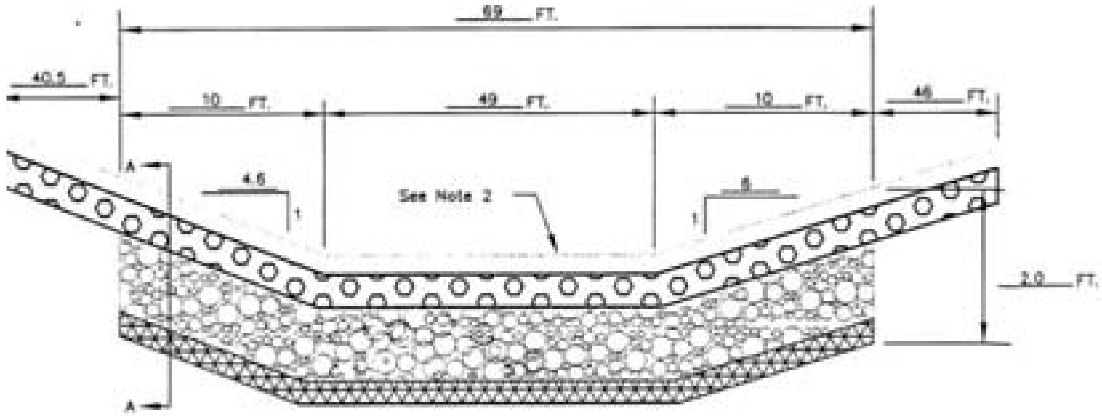
Properly designed and installed hardened crossings provide a safe, permanent area for livestock and equipment to cross streams without becoming bogged in the mud.

Advantages

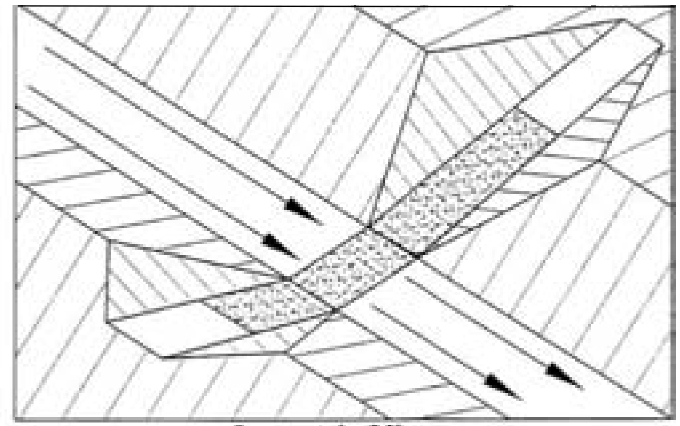
- Easily adapted to various stream sizes and locations
- Quick installation
- Long useful life
- Low maintenance
- Does not create stream obstruction
- Does not impair stream flow
- When used in conjunction with fencing, improves water quality by limiting livestock access to stream.
- Does not require poured concrete

Limitations

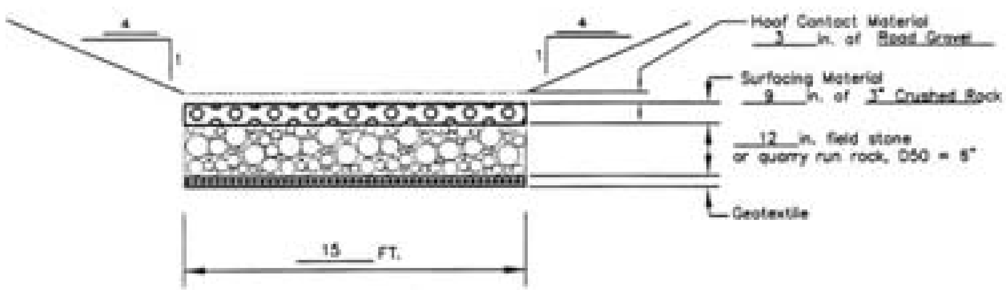
- Can be expensive



Profile Along Centerline of Crossing



Isometric View



Cross Section A-A

Quantities

Excavation	663	CU. YD.
Sand and Gravel	–	CU. YD.
Quarry Run Rock or Field Stone, D50 = 6"	39	CU. YD.
Crushed Rock, D50 = 3"	66	CU. YD.
Hoof Contact Material, 3/4" Road Gravel	23	CU. YD.
Geotextile Fabric Class 4 (Woven) (Nonwoven)	260	SQ. YD.
Seeding	0.1	ACRES

Surface Material Gradation

Percent Passing By Weight	3" Size (inches)	6" Size (inches)
100	6"	12"
60–85	4.5"	9"
25–50	3"	6"
5–20	1.5"	3"
0–5	0.6"	1.2"

Notes:

1. Compact the surfacing material with a minimum of one pass of heavy wheeled/tracked equipment.
2. The cross sectional area of the creek channel shall not be reduced by the crossing. The top most layer of surfacing material shall be level to 0.2' below the channel elevation.
3. Only the geotextile, hoof contact material, and 3" crushed rock shall be installed on the approaches to the creek crossing.

Hardened Surface Access

Design Considerations

Crossings should always be placed on riffles — never in pools — and should be placed perpendicular to stream flow.

The crossing surface should be at an elevation equal to streambed elevation. Geotextile fabric should be placed under the rock or gravel fill material.

This practice may require permits. Please read the permit section of this handbook (p. 143).

Super-Insulated Waterer

Overview

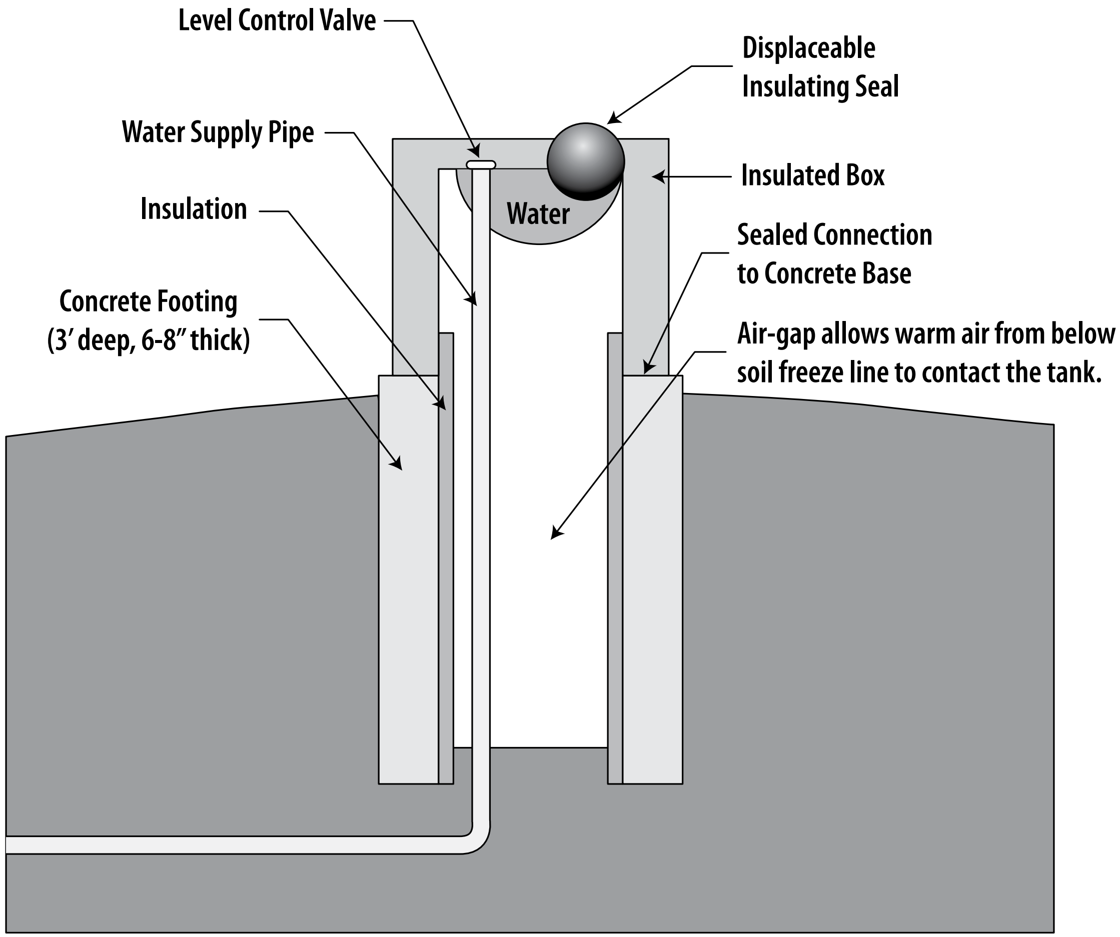
Ice-free water is a challenge for livestock producers in colder climates. Experience with many different types of waterers has led major companies and producers to consider products with much higher insulation values (R-factor – resistance to heat flow). Producers have reported problems with heating elements or burners in their waterers that are designed to preventing freezing. Greater acceptance of molded-plastic use around livestock has led to manufacture of super-insulated plastic waterers. In most cases super-insulated waterers have operated very well in the central U.S. without use of auxiliary electric heating elements or gas burners.

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
- Does not rust
- Uses UV-resistant molded plastic

Limitations

- Requires more frequent checking than other types of waterers
- Can be damaged if allowed to freeze repeatedly (left with no livestock)
- Requires a solid or concrete base


Level Control Valve
Displaceable
Insulating Seal
Water Supply Pipe
Insulated Box
Water
Insulation
Sealed Connection
to Concrete Base
Concrete Footing
(3′ deep, 6-8″ thick)
Air-gap allows warm air from below
soil freeze line to contact the tank.

Super-Insulated Waterer

Design Considerations

Combining use of a vertical "earth tube" into the ground below the waterer with the warmth of the water as it enters the waterer generally provides enough energy to prevent ice from forming inside the waterer. When water colder than normal groundwater temperature is used, such as pond water or spring water, the chance of freezing is greater.

These waterers utilize a variety of doors or covers to retain the intrinsic heat of the water and to seal cold air and wind out. Most waterers use either a large ball that floats tight against the inside of the tank or a door that the livestock open in order to access the water. Occasionally these doors or balls will freeze shut; however, a bump or tap by the producer will open the door or dislodge the ball. Livestock easily learn how to access the water.

These tanks rely on a significant volume of warmer water to prevent freezing, so the number of livestock per waterer should be adjusted to ensure that the waterer will refill periodically with warmer water. The producer will normally find that in the central U.S., a flow through (or use) of two or three volumes of water is required on the coldest days to prevent freezing. Most companies recommend at least 10-15 head per waterer. These waterers can be placed in a fence line to allow more livestock to use a waterer.

Producers are cautioned to check these energy free waterers twice a day; in the morning to make sure that livestock can access the water, and again near evening to assure the float and valve are operating properly.

Super insulated waterers should be placed in a location protected from the wind and snow to minimize heat loss and reduce the chance of freezing. A site exposed to the sun also reduces the probability of the waterer freezing.

Most super-insulated waterers require a solid base such as a concrete pad. A good gravel base around the concrete pad should be considered. Refer to "Geotextile and Gravel Surrounds" on p. 123.

Bottomless Tank

Overview

Bottomless tanks are large, open-topped tanks used for storing water and watering livestock. They are most 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 PVC plastic membrane.

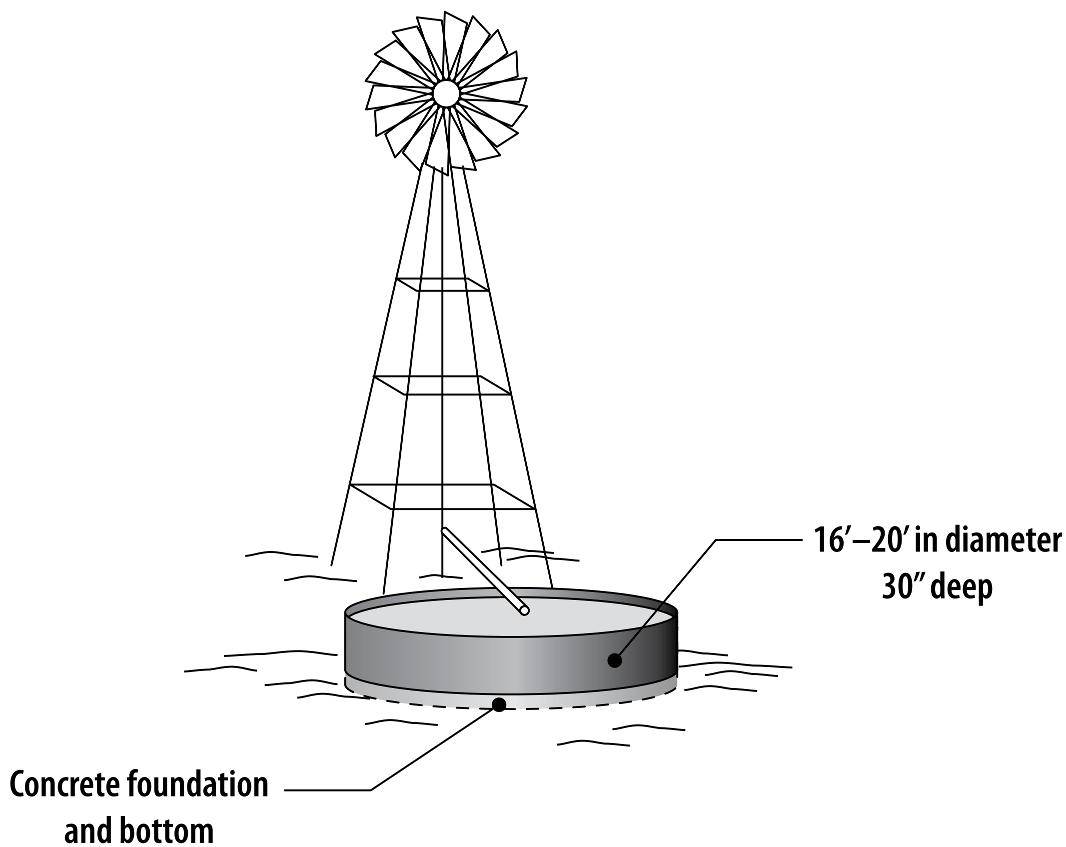
Because bottomless tanks come unassembled, very large (20 feet or larger diameter) tanks are possible. Tanks this size would be prohibitively expensive to ship if they were already assembled. Because of their water storage capacity these tanks can compensate for the variable water output of windmill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

Advantages

- Simple construction
- Easily adaptable to most sites
- Large capacity at comparatively low cost compared with 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
- Can be relocated, but only with much time, effort and expense


16′–20′ in diameter
30″ deep
Concrete foundation
and bottom

Bottomless Tank

Design Considerations

Bottomless tanks are generally 25-30 inches deep and 20 feet or more in diameter. The lower part of the 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.

Tire Tank

Overview

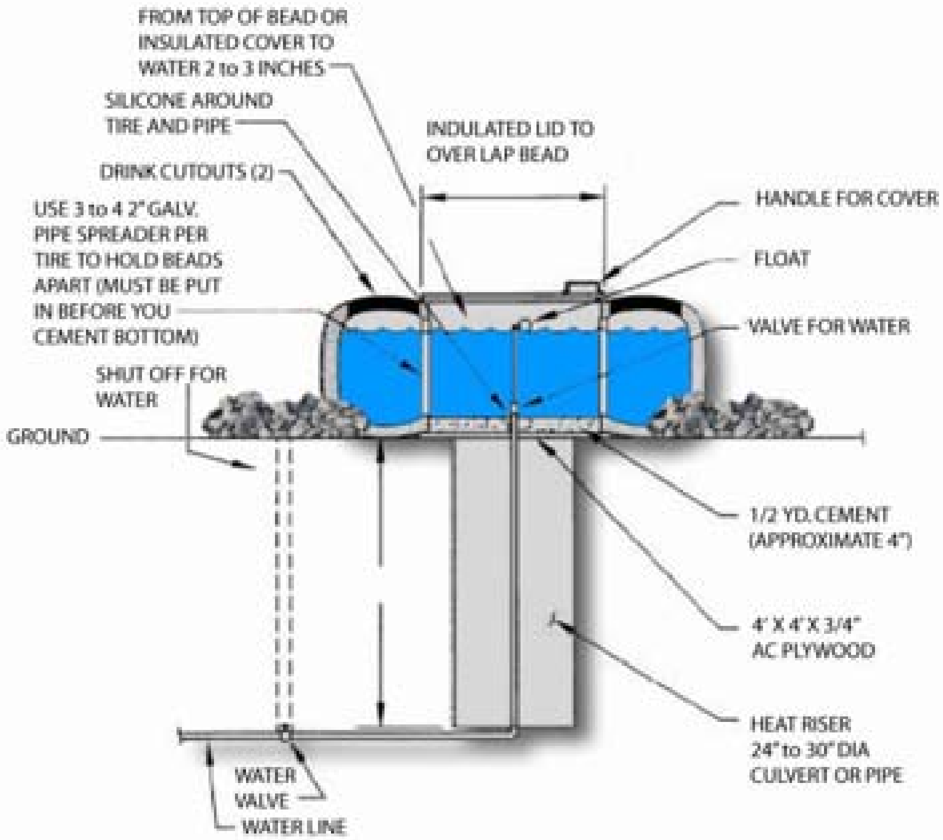
Used rubber tires from heavy earth-moving or construction equipment have been adapted for use as reliable livestock water tanks. They have proven to be durable, relatively inexpensive, and capable of being used with a variety of water sources. In numerous situations and settings, they are freeze-resistant in winter.

Advantages

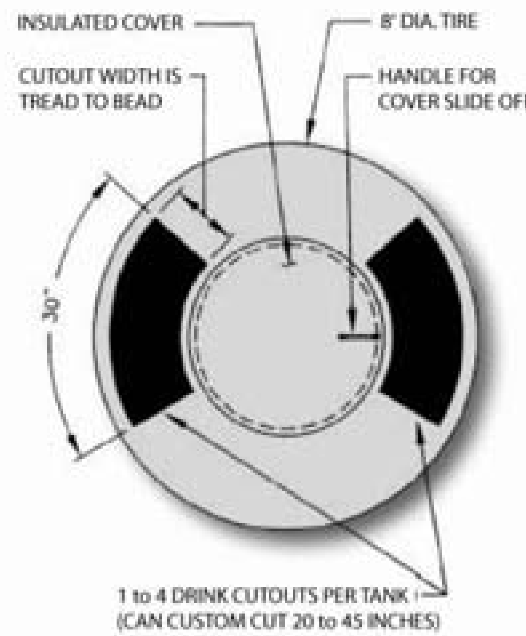
- Simple and generally inexpensive
- Available in a variety of sizes
- Durable and non-breakable; no sharp edges to injure livestock
- Can be used with waterlines from wells, springs, and new or existing ponds
- Freeze-resistant in winter if some protection provided

Limitations

- Heavy to handle during installation
- Limited size may limit water storage for larger herds
- Removal of part or all of one sidewall to make tank is usually difficult



SIDE VIEW



TOP VIEW

Tire Tank

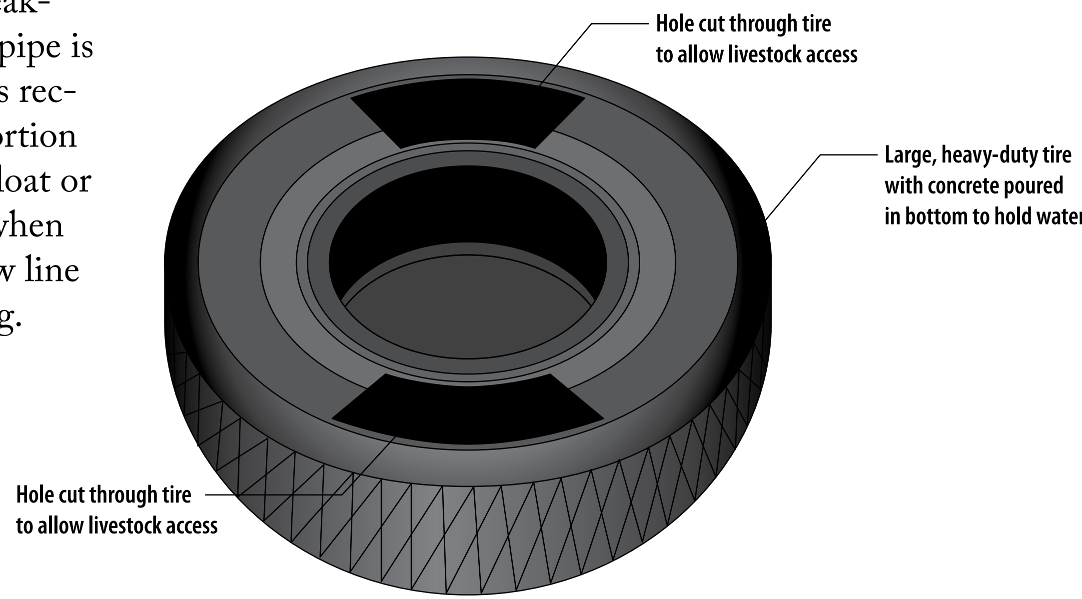
Design Considerations

Rubber tire tanks are normally supplied via pipeline from wells, springs or ponds. Choose tanks based on the size of the herd to be watered and the supply rate of the water source. Sizes range from 5 to 15 or more feet in diameter. Width of the tire (tank height) can be as much as four feet. The sidewall of the tire is cut away in part or entirely on the topside to allow drinking access. Cutting fewer holes will improve the freeze resistance of the tank while cutting away the entire sidewall will allow more livestock to drink at one time. Larger tires can be partially buried for some protection from freezing and to reduce the height of the tires, allowing access for smaller animals. Use a heavy-duty saw to cut and remove part or all of the sidewall on the upper side to allow livestock easy access to water.

The pipeline riser supplying the water (inlet) should be placed in the center of the tire or otherwise protected from breakage by livestock. A supply line of one to two inch PVC pipe is generally installed. A pipe joint at the base of the riser is recommended to allow easy replacement in case the top portion is broken. Most tire tanks are fitted with some type of float or shut-off valve. An overflow line is not installed except when the tank is part of a spring development and an overflow line is needed to carry away excess inflow or prevent freezing.

Use concrete, bentonite or other heavy clay to seal the lower side of the tire at ground level to prevent leakage. Tanks may be partially buried or soil mounded part of the way up the sides to reduce fluctuations in water temperature. Placing a layer of coarse gravel or other similar material around the tank will provide a durable, hardened surface and eliminate muddy conditions. Placing a "deck" of used railroad ties adjacent to the tire will help give small calves access to the water. Building a protective railing over the tank is recommended to keep animals from being pushed into the tank and away from piping and floats.

Most rubber tire tanks can be installed for a few hundred dollars. Some construction companies will give away used tires at construction sites simply to have them removed. Tires are also available from several suppliers. Examples of tire tanks can be viewed at *www.wenzelconstruction.com/rubbertiretanks.html*.



Fiberglass or Galvanized Tank

Overview

Portable tanks are an important part of livestock watering. Galvanized steel and fiberglass tanks are the two types commonly used. They are considered portable because they are reasonably light weight compared with other options. Empty tanks are easy to move for a temporary need. Tanks are suitable for watering a large number of animals at a time and are generally economical.

Advantages

- Water quality in a tank is usually better than cattle drinking directly from a pond
- A single tank can serve more than one paddock or lot
- Can be easily moved when needed
- Can be located/relocated to improve cattle distribution in a paddock
- A large tank allows several animals to drink at once
- Because of stored water the larger the tank the smaller the water delivery capacity needed to supply the animals
- Tanks work well for hauled water
- Portable tanks can be moved regularly to avoid mudholes developing around the tank

Limitations

- Soil around the waterer can become muddy from cattle dripping and depressions that develop and collect rainfall
- Manufactured tanks may be more costly than a used tire tank and are more susceptable to damage
- Galvanized steel and fiberglass tanks don't last as long as concrete tanks; probably not the best choice for a permanantly-located waterer
- Galvanized tanks will eventually rust
- Empty and unsecured tanks can be blown away or stolen
- Large tanks are awkward to move

Fiberglass or Galvanized Tank

Design Considerations

Tanks should be sited on well-drained level ground. Water should drain away from the tank to help avoid a mud hole around the tank site. Be sure the site is prepared by removing any rocks and making the area level. Sharp rocks can puncture the bottom of tanks. Galvanized and fiberglass tanks that are supplied by a gravity or pressured water source need a method to prevent overflow. Options include floats that will shut off the water supply when the tank is full or an overflow that drains by gravity into a low spot or draw that is at least 50 feet from the tank.

The tank should be sized to meet the needs for the number of animals it will supply. If the pasture is large, the tank should be able to supply all animals within about 30 minutes (a drinking event) without lowering the water level more than about 10 inches. This means that the water contained in the 10-inch water-level drop plus the inflow during the drink time are adequate to supply one drinking event.

During the winter, water in tanks will freeze on the surface and holes must be chopped through the ice so cattle can drink. When sufficient flow is available, tanks fed by groundwater should have an overflow to allow a trickle or low flow through it during the winter to minimize freezing. Groundwater is a fairly constant temperature of about 55 degrees in Kansas.

To avoid mud around permanent tank locations, the space around the tank should be protected by a hard surface or draining hard material such as gravel or geotextile-gravel surfacing. Rock that is about 2 inches in diameter will be uncomfortable enough that cattle won't linger by the water and destroy surrounding vegetation. Concrete is an excellent long life surfacing material but is expensive. Soil cement or fly ash should be less expensive options that provide a durable hard surfacing, but with a shorter life than concrete.

Portable tanks can easily be moved from time to time to avoid destroying grass and creating a mud hole. Water supply lines can be flexible above ground pipe.

Livestock Management Practices

Hardened Mat

Overview

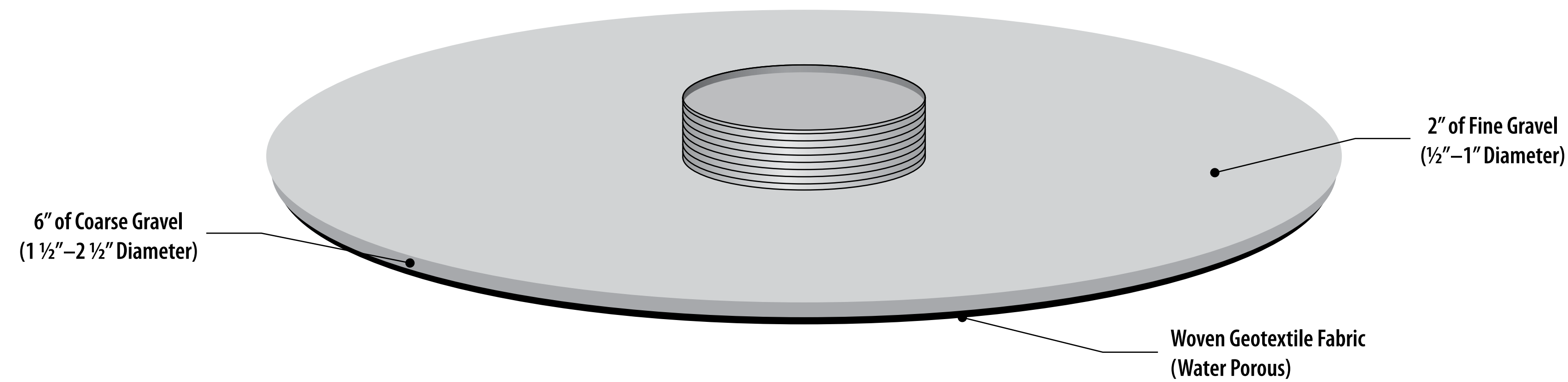
Watering sites frequently become muddy due to excess water, urine, and manure deposited near the waterer. Geosynthetic material and gravel cover on the area around the waterer provide a hardened surface, reduce animal stress due to mud, provide solid footing, and allow excess water to drain way instead of pooling around the waterer. There are 2 types of geosynthetics: geotextiles (a fabric material) and geogrids (a cross-hatched or honeycombed grid that holds rock). The fabric forms a continuous layer over the surface of the ground; the plastic expandable grid holds rock in place. Both geotextiles and geogrids are covered or filled with rock, fly ash, or other material that allows water to drain through the suface.

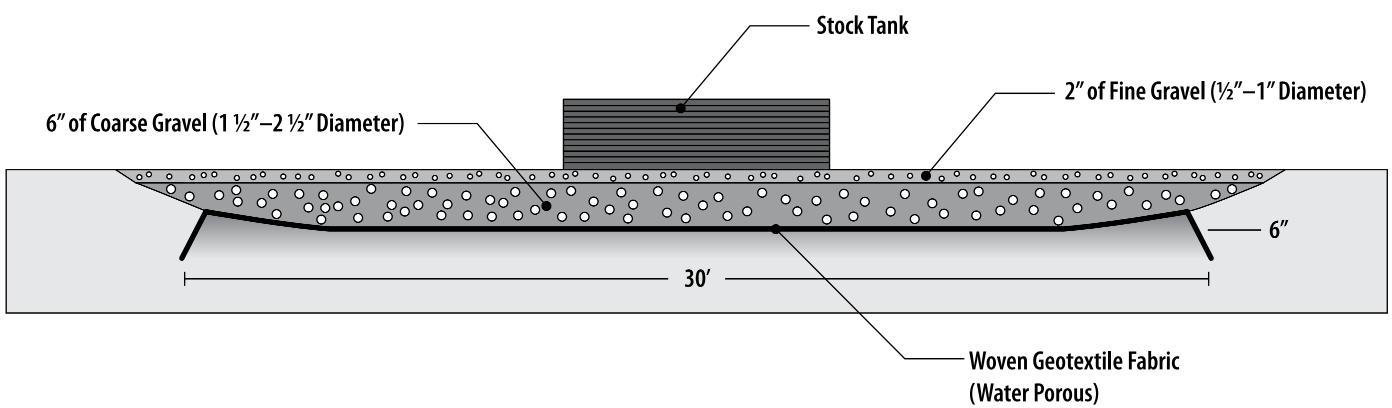
Advantages

- Keeps rock from working into the ground and disappearing
- Provides solid footing for animals and humans around the watering site
- Excess water percolates back into the soil
- Rock discourages livestock from loitering around the tank, allowing all animals a chance to drink and reducing manure and urine deposits
- Much less expensive than concrete
- Easily installed by producer
- No special tools needed for installation
- Minimal preparation time needed for installation
- Reduces runoff and erosion

Disadvantages

- Less permanent than concrete


2″ of Fine Gravel
(½″–1″ Diameter)
6″ of Coarse Gravel
(1 ½″–2 ½″ Diameter)
Woven Geotextile Fabric
(Water Porous)


Stock Tank
2″ of Fine Gravel (½″–1″ Diameter)
6″ of Coarse Gravel (1 ½″–2 ½″ Diameter)
6″
30′
Woven Geotextile Fabric
(Water Porous)

Hardened Mat

Design Considerations

A geosynthetic and gravel-hardened mat works best on 7-8 percent slopes so water will drain away from the site. The surround should extend 8-12 feet on all sides of the waterer to which livestock have access.

Geosynthetic textile can be laid directly on top of existing grass, but woody vegetation must be removed prior to installation. For more secure installation, a 6 inch deep trench can be made with a single chisel point. The edge of the geotextile is pushed into the trench and then the entire surface is covered with a 4-6 inch layer of coarse rock (2-3 inch diameter). A top surface of fines is desirable for a more stable and comfortable surface. Fly ash, small gravel or finely crushed limestone make a good surface. Mixed-diameter river rock with the sand removed will also make a good surface.

Minimal maintenance is needed to keep the surface in good condition. Excess manure can be hauled away after livestock are removed from the pasture. Additional rock may be needed after 5-10 years.

Geotextile cloth can be obtained from highway departments and conservation districts.

A hardened impermeable surface has the disadvantage that water cannot percolate through it. However, it may be more durable and have a longer life than gravel over geotextile. Options for this type of surface include concrete, soil cement, and a layer of fly ash that will set up when wet.

Grazing Management Changes for Water Quality

Overview

Allowing livestock to have direct access to streams and ponds can have negative impacts to bank stability, water quality, livestock performance and aquatic organisms. Fencing to exclude livestock often is recommended as a practice to protect streams and ponds. In many instances, similar protection can be provided by changing grazing management systems.

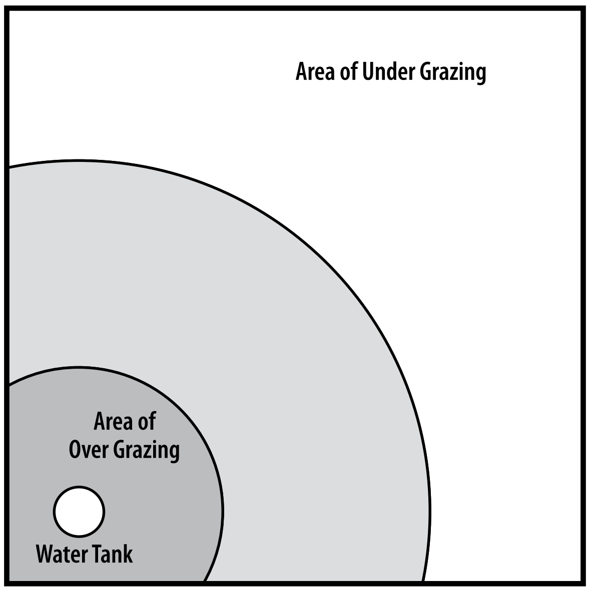
Paine and Lyons (1999) reported that good grazing management, including rotational grazing, can protect stream banks and riparian areas nearly as well as ungrazed buffer strips. These authors also reported that grassy buffers are better than woody buffers along small streams. Fecal coliform bacteria and turbidity were consistently higher at continuously grazed sites when compared with rotationally grazed sites along small Minnesota streams (Sovell et al. 2000). Researchers in Iowa believe the major source of sediment and phosphorus from grazed pastures comes from streambank erosion. Paine and Lyons found that pastures managed with short-duration grazing had significantly less bank erosion than continuously grazed pastures with buffer strips.

Advantages

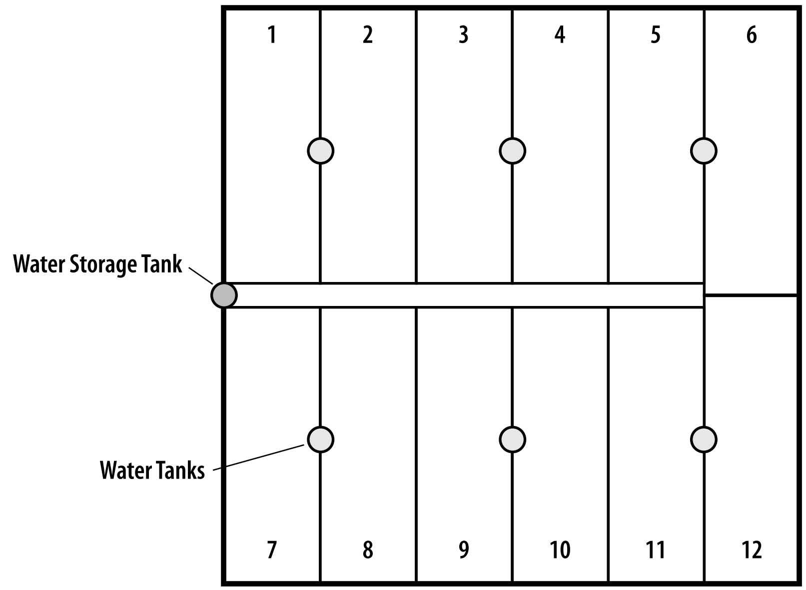
- Rotation grazing improves vigor and density of riparian vegetation
- More acceptable to livestock producers than fencing off streams
- Less cost to implement and maintain than streamside fences

Limitations

- Not well suited to larger streams



Traditional quarter section of grass with no cross-fencing



Rotational grazed quarter section with 12 paddocks

The area around each water source is grazed more heavily. Placing additional water sources in more lightly grazed areas of a paddock can result in both reduced overgrazing around the original water source and increased grazing in less utilized areas of the paddock.

Many different grazing schemes can be used to maximize livestock grazing while protecting vegetation and water. All rotations involve providing a period of rest for the vegetation to recover after grazing. When designing a rotation, consider the following:

- *length of time required for vegetation to recover (will change over the course of the growing season)*
- *frequency of rotation*
- *ease of moving livestock between paddocks*
- *livestock production goals*
- *environmental and ecological goals (water quality, wildlife habitat)*

Grazing Management Changes for Water Quality

Design Considerations

Fencing designs that create a grazeable unit around a pond or along a stream allow short-term use at times when the banks are dry and stable. Fencing a grazing unit of the flood-plain adjacent to a stream eliminates flood damage to fences and separates upland from lowland soils. Rotational grazing systems to allow flash grazing of sensitive areas, followed by extended rest, will improve the density and cover of grasses.

Provide access lanes with stable footing to the water sources for livestock drinking. Locate salt, mineral and back rubs away from the water. Remove any trees near the water where livestock congregate and provide shade away from the water if needed.

References:

Paine, L. K. and J. Lyons. 1999. Managed grazing and stream ecosystems. Streamside Grazing Workshop, September 8-9, 1999, Eagle Bluff Center, Lanesboro, Minn.

Sovell, L., A.B. Vondracek, J.A. Frost, and K.G. Mumford. 2000. Impacts of rotational grazing and riparian buffers on physicochemical and biological characteristics of south-eastern Minnesota, USA, streams. Environmental Manage. 26(6):629-641.

Haan, M., J. Russell, D. Morrical, D. Strohbehn, W. Powers, J. Kovar. 2006. Effects of grazing management on pasture characteristics affecting sediment and phosphorus pollution in pasture streams (Progress Report). A.S. Leaflet R2122. Iowa State University Animal Industry Report 2006, Iowa State Univ., Ames. *http://www.ans.iastate.edu/report/air/2006pdf/R2122.pdf*

Fencing the Pond

Overview

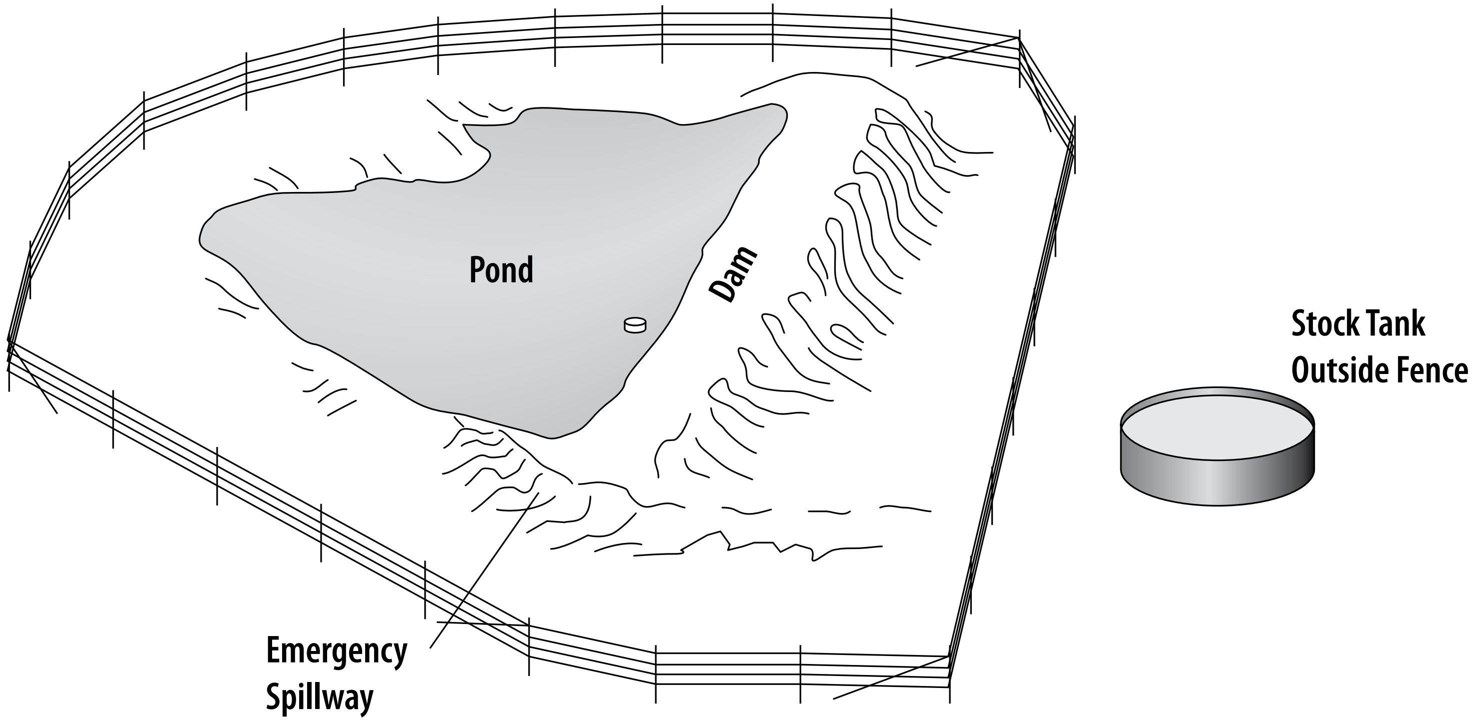
Ponds dot the landscape over much of Kansas and are important sources of livestock water. Many serve other functions, such as runoff retention and habitat for aquatic life. Most ponds lose some usefulness over time due to erosion and sedimentation. Useful pond life is extended by fencing completely around the pond to restrict livestock access. A fenced pond will require installation of a pipeline through the dam to a tank, construction of an access ramp, or some other means of supplying water to livestock, such as pumping.

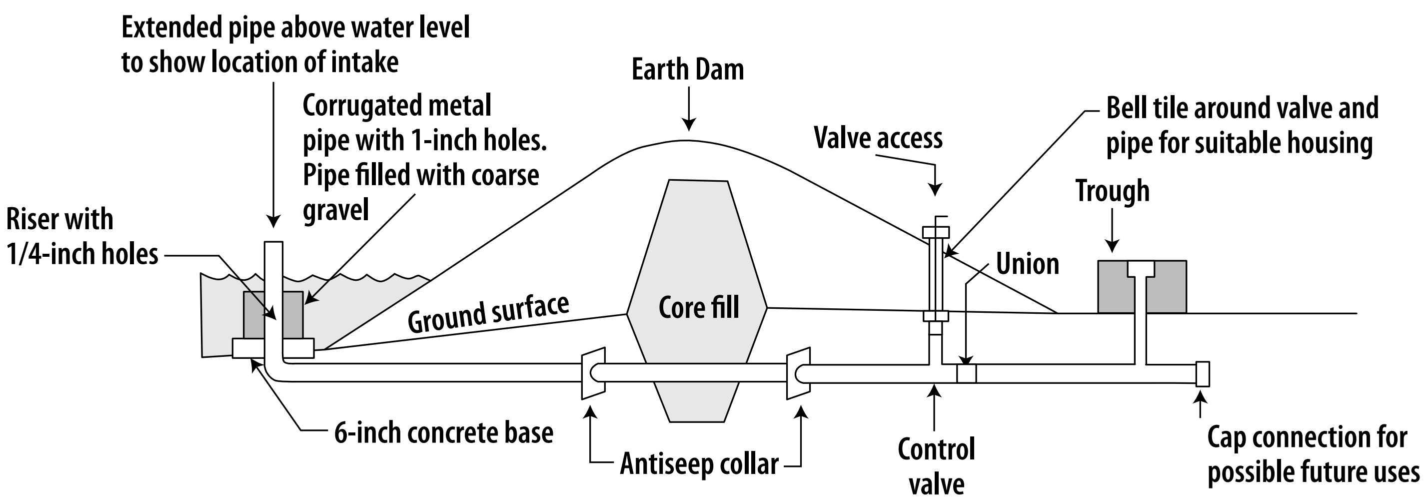
Advantages

- Minimizes erosion of pond shorelines and dam faces
- Reduces sediment deposition in reservoir
- Extends useful life of the pond
- Improves quality of water for livestock and aquatic life
- Better wildlife habitat along the shoreline
- Prevents cattle from getting on ice during winter and falling into pond
- Eliminates animal trails in the emergency spillway (which lead to spillway erosion and possible failure)
- Eliminates or minimizes fecal oral transmission of diseases through water

Limitations

- Additional cost for fence construction; numerous corners and rough terrain add to the cost





Pipe with antiseep collars

Fencing the Pond

Design Considerations

The decision to construct a fence around a livestock water pond requires planning. Consider how water can be provided to livestock from the pond once it is fenced. Most commonly, a pipeline is installed under a new dam during construction or around or through an existing dam as a retrofit, allowing water to flow by gravity pressure to a tank or waterer below the dam. Construction of an access lane or ramp to the edge of the reservoir is another option. Use of a nose pump is also a consideration.

The fencing layout should provide a suitable buffer between the edge of the reservoir and the grazed pasture outside the fence. At least 30 feet of buffer is needed to filter out sediment and other materials. These buffers are potential areas for ground-nesting birds; if buffers are made too narrow, they become easy hunting zones for predatory animals. Testing the layout of a pond fence with electric fencing for a year or two may reveal flaws in the design.

A standard fence of four barbed wires and posts at 16-20 foot intervals is adequate in most situations. Minimizing the number of sharp corners, especially on steeper slopes, will reduce potential erosion from cattle trailing. Installing gates at two locations will allow access for flash grazing if needed to manage the vegetation and provide emergency access to the reservoir for livestock and fire control equipment.

Supplementary Materials

Water Volume Requirements for Livestock (gal./day)

Increased temperature, salt, and protein increase water needs

		Average	lbs. water	Air Temperature		
		(gal./day)	*/lb. dry feed*	*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

* A good rule of thumb is that a horse needs at least a gallon of water per 100 lbs of body weight. For your 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. For instance, if your horse is exercising in hot, humid weather, he may need 2-4 times the minimum amount.

Sources:

Cummings School of Veterinary Medicine. 2006. Dehydration and electrolyte losses in the sport horse. Tufts University., Medford, Mass. *http://www.tufts.edu/vet/sports/dehydration.html#req*

Guyer, P. 1977. Beef cattle nutrition. Lincoln NebGuide 8. Univ. of Nebraska, Lincoln.

Landefeld, M. and J. Bettinger. 2002. Livestock water development. Fact Sheet ANR-12-02. Ohio State Univ. Extension., Columbus, Ohio.

Midwest Plan Service. 1975. Private water systems handbook, 4th edition, MWPS-14, Ames, Iowa.

National Research Council. 1996. Nutrient requirements for beef cattle, 7th edition. National Academy Press, Washington, DC.

Siting Watering Facilities

The location of the watering site determines herding behavior and drinking patterns. Here are some suggested watering locations:

- **In each pasture:** Animals tend to drink one at a time if water is provided in pastures 10 acres or less in size. A flow rate of 2-6 gallon per minute will keep a 25-35 gallon tank full. Change the tank location along the fence line to allow sod to recover in former watering areas. A trough in each pasture will keep animals and manure on the grass and out of the lanes.
- **Away from feed, minerals and shade:** Distribute these items through the pasture. This will discourage loitering in one area and disperse grazing. Provide water outside of the barn or livestock may stay in the barn on hot days and not pasture at all.
- **More than 100 feet from open water:** Animals concentrate manure and mud at watering sites. This can create "hot spots" for erosion and polluted runoff. Leave a healthy buffer between watering sites and watercourses.
- **Less than 500 feet between water sources:** If water is far away or located outside the pasture, then animals will travel as a herd to the water and drink as a herd. In a herd situation, livestock will graze unevenly, concentrate in the watering area, and "boss" animals may prevent timid animals from drinking. If this situation can't be avoided, be sure to have enough space at the water source for 10 percent of the herd to drink at any time. Each drinking animal should have 20 inches of space at a circular tank and 30 inches at a straight tank.

Reprinted from:

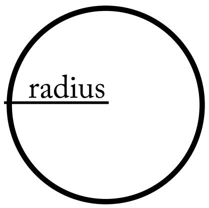
Oregon Association of Conservation Districts. 2006. Managing stockwater in pastures and streamside areas. Tualatin Soil and Water Conservation District, Hillsboro. *http://www.oacd.org/factsheet_09.html*

Calculating Tank Capacity

To calculate capacity of a tank, use the formula below that most closely resembles the shape (top) of your tank.

Convert all measurements to inches!

Circle

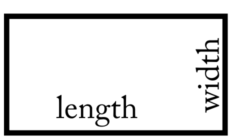


$$\frac{\pi \times \text{radius}^2 \times \text{water depth}}{231} = \text{gallons}$$

Example:
$\pi = 3.14$
Radius = 42”
Water depth = 24”

$$\frac{3.14 \times 42'' \times 24''}{231} = \frac{132{,}935}{231} = 575 \text{ gallons}$$

Rectangle



$$\frac{\text{length} \times \text{width} \times \text{water depth}}{231} = \text{gallons}$$

Example:
Length = 84”
Width = 26”
Water depth = 24 “

$$\frac{84'' \times 26'' \times 24''}{231} = \frac{52{,}416}{231} = 227 \text{ gallons}$$

Available Water
Gallons of water per inch can be important if livestock cannot reach the bottom of the tank and you need to know the amount of water available for them. It is also important if the tank is partially empty and you need to know the amount remaining in the tank.

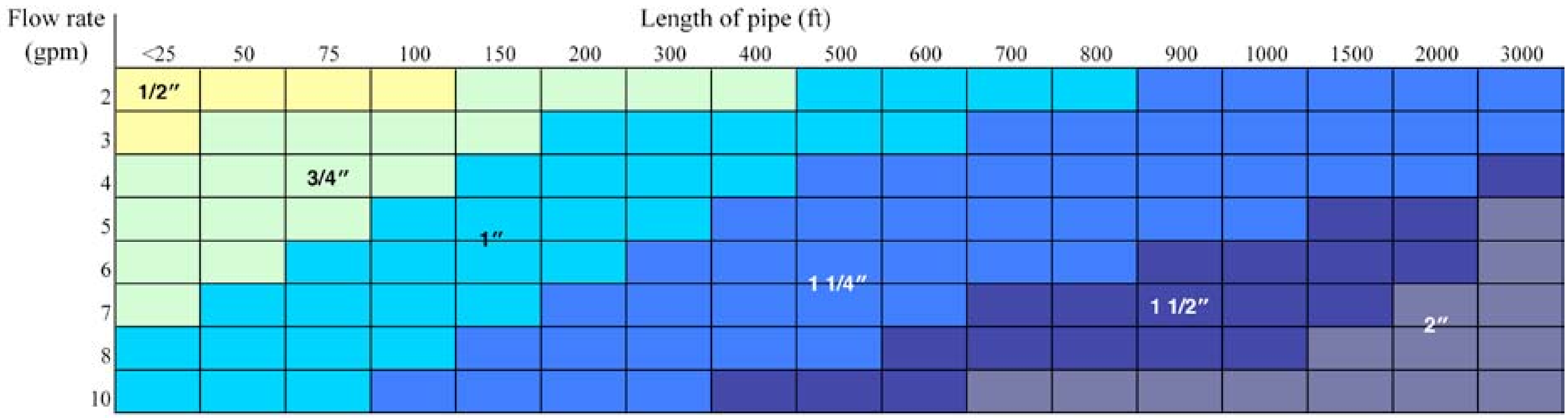
$$\frac{\text{total tank capacity (gallons)}}{\text{depth.}} = \text{gallons/inch}$$

Example:
Tank capacity = 575 gallons
Tank depth = 24”

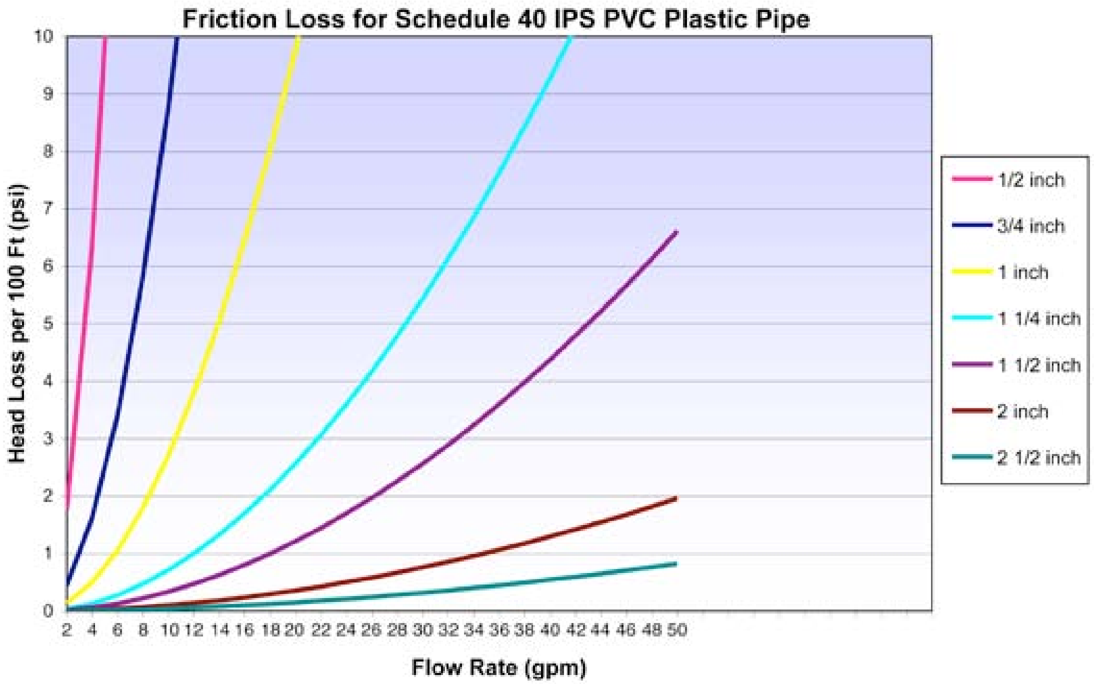
$$\frac{575}{24} = 23.9 \text{ gallons / inch}$$

Adapted from: Landefeld, M. and J. Bettinger. 2002. Livestock water development. Fact Sheet ANR-12-02. Ohio State Univ. Ext., Columbus.

Recommended* Pipe Diameter (inches) for Given Flow Rates and Pipeline Lengths



*Schedule 40 Thermoplastic Pipe, outdoor application
Adapted from: Midwest Plan Service. 1975. Private Water Systems Handbook, 4th ed. Ames, Iowa. ©


Friction Loss for Schedule 40 IPS PVC Plastic Pipe
Head Loss per 100 Ft (psi)
0
1
2
3
4
5
6
7
8
9
10
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
Flow Rate (gpm)
1/2 inch
3/4 inch
1 inch
1 1/4 inch
1 1/2 inch
2 inch
2 1/2 inch

Pipe Size (inches)	1/2			3/4			1			1 1/4			1 1/2			2			2 1/2		
OD (inches)	0.840			1.050			1.315			1.660			1.900			2.375			2.875		
ID (inches)	0.622			0.824			1.049			1.380			1.610			2.067			2.469		
Volume (gal/100')	1.578			2.770			4.490			7.770			10.576			17.432			24.871		
Wall Thickness	0.109			0.133			0.133			0.140			0.145			0.154			0.203		
Flow Rate (gpm)	friction loss in psi/ 100 ft	friction loss in ft/ 100 ft	velocity in the pipe in ft/sec	friction loss in psi/ 100 ft	friction loss in ft/ 100 ft	velocity in the pipe in ft/sec	friction loss in psi/ 100 ft	friction loss in ft/ 100 ft	velocity in the pipe in ft/sec	friction loss in psi/ 100 ft	friction loss in ft/ 100 ft	velocity in the pipe in ft/sec	friction loss in psi/ 100 ft	friction loss in ft/ 100 ft	velocity in the pipe in ft/sec	friction loss in psi/ 100 ft	friction loss in ft/ 100 ft	velocity in the pipe in ft/sec	friction loss in psi/ 100 ft	friction loss in ft/ 100 ft	velocity in the pipe in ft/sec
2	1.76	4.07	2.11	0.45	1.03	1.20	0.14	0.32	0.74	0.04	0.08	0.43	0.02	0.04	0.32	0.01	0.01	0.19	0.00	0.00	0.13
4	6.35	14.67	4.22	1.62	3.73	2.41	0.50	1.15	1.48	0.13	0.30	0.86	0.06	0.14	0.63	0.02	0.04	0.38	0.01	0.02	0.27
6	13.45	31.05	6.34	3.42	7.89	3.61	1.06	2.44	2.23	0.28	0.64	1.29	0.13	0.30	0.95	0.04	0.09	0.57	0.02	0.04	0.40
8				5.82	13.44	4.81	1.80	4.15	2.97	0.47	1.09	1.72	0.22	0.51	1.26	0.07	0.15	0.76	0.03	0.06	0.54
10				8.80	20.31	6.02	2.72	6.27	3.71	0.71	1.65	2.15	0.34	0.78	1.58	0.10	0.23	0.96	0.04	0.10	0.67
12				12.33	28.46	7.22	3.80	8.78	4.45	1.00	2.31	2.57	0.47	1.09	1.89	0.14	0.32	1.15	0.06	0.14	0.80
14							5.06	11.68	5.20	1.33	3.07	3.00	0.63	1.45	2.21	0.19	0.43	1.34	0.08	0.18	0.94
16							6.48	14.95	5.94	1.70	3.93	3.43	0.80	1.86	2.52	0.24	0.55	1.53	0.10	0.23	1.07
18							8.05	18.59	6.68	2.12	4.89	3.86	1.00	2.31	2.84	0.30	0.68	1.72	0.12	0.29	1.21
20							9.79	22.59	7.42	2.57	5.94	4.29	1.22	2.81	3.15	0.36	0.83	1.91	0.15	0.35	1.34
22							11.68	26.95	8.17	3.07	7.09	4.72	1.45	3.35	3.47	0.43	0.99	2.10	0.18	0.42	1.47
24										3.61	8.33	5.15	1.70	3.93	3.78	0.50	1.16	2.29	0.21	0.49	1.61
26										4.18	9.66	5.58	1.97	4.56	4.10	0.58	1.35	2.49	0.25	0.57	1.74
28										4.80	11.07	6.01	2.26	5.23	4.41	0.67	1.55	2.68	0.28	0.65	1.88
30										5.45	12.58	6.44	2.57	5.94	4.73	0.76	1.76	2.87	0.32	0.74	2.01
32										6.14	14.18	6.86	2.90	6.69	5.04	0.86	1.98	3.06	0.36	0.83	2.14
34										6.87	15.86	7.29	3.24	7.49	5.36	0.96	2.22	3.25	0.40	0.93	2.28
36										7.64	17.63	7.72	3.60	8.32	5.67	1.07	2.46	3.44	0.45	1.04	2.41
38										8.44	19.48	8.15	3.98	9.20	5.99	1.18	2.72	3.63	0.50	1.15	2.55
40										9.28	21.42	5.58	4.38	10.11	6.30	1.30	2.99	3.82	0.55	1.26	2.68
42										10.16	23.45	9.01	4.79	11.07	6.62	1.42	3.28	4.02	0.60	1.38	2.81
44													5.45	12.57	7.09	1.61	3.72	4.30	0.68	1.57	3.02
46													5.67	13.10	7.25	1.68	3.88	4.40	0.71	1.63	3.08
48													6.14	14.17	7.56	1.82	4.20	4.59	0.77	1.77	3.22
50													6.62	15.28	7.88	1.96	4.53	4.78	0.83	1.90	3.35

Calculating Wet Well Capacity

Installation of ½ inch diameter crushed stone creates approximately 35% void space that would provide about 3 gallons of additional water storage for each cubic foot of crushed stone.

Pipe and Screen Diameter (in.)	Volume Per 100 Lin. Ft. (ft.^{3})	Volume of Water Storage (gal.)
4	9	67.3
6	20	149.6
8	35	261.8
12	79	590.9
24	314	2,348.7

Gravel Backfill (ft.^{2})	Volume Per 100 Lin. Ft.(ft.^{3})	Volume of Water (gal.)
1 (12 X 12)	35	262
2 (12 X 24)	70	524
3 (12 X 36)	105	785
4 (12 X 48)	140	1,047

- Assumes well graded ½ crushed limestone rock gravel backfill.
- Assumes 35% voids in crushed rock gravel backfill.

Permits in Kansas

Knowing the requirements related to building, removing, or altering federal and state waters (including wetlands) could save time and money. Producers can avoid delays associated with investigations, lengthy processing procedures, or possible litigation. It may also help reduce the potential for a registered public complaint or civil lawsuit, as well as save taxpayer dollars, while protecting beneficial uses of state waters for yourself and citizens of Kansas and border states.

Permits should be secured prior to construction to avoid costly rework or additional permit fees. It is recommended that you start the permit application process well in advance of your anticipated construction start date. A 30-day comment period is required, at a minimum, for notification of interested and concerned agencies and organizations. The total time to process an application can be several months.

Several agencies permit water development in Kansas. You will need to obtain permits seperately from each permitting agency. Below is a summary of the various permitting agency requirements. This is not an exhaustive listing, and regulations are subject to change. For each agency, contact information is provided to direct you to permit regulations, downloadable permit forms and/or agency contact information.

Kansas Department of Agriculture, Division of Water Resources

The water structures program regulates manmade structures affecting the flows and overflows of any stream by ensuring, within limits imposed by laws and courts, that such structures are properly planned, constructed, operated and maintained for their authorized purposes without 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: 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, grassed waterways, levees along streams, placement of fill within the floodplain, and gravel/sand dredging.

You will not need a dam permit from KDA if your dam:

- is less than 25 feet in height, and has a total capacity of less than 50 acre feet of water at the top of the dam, or
- is less than 6 feet in height.

Your dam may still need a permit as a stream obstruction (as would any other project located in a stream channel) if the watercourse is defined as a stream by KDA's chief engineer. Generally speaking, in eastern Kansas a watercourse is a stream for regulatory purposes if the drainage area upstream of the project location is more than 240 acres, while in central Kansas the limit is 320 acres and in western Kansas the limit is 640 acres.

It is recommended that you ask KDA for a determination about your planned project to confirm whether or not a permit is needed.

(785) 296-3710

Permits in Kansas

Before developing a source of livestock water, you may need a permit to appropriate water for stockwatering purposes according to state law. If you plan to water your livestock from a pond and you plan to impound more than 15 acre-feet of water, approval of an application will be necessary before construction begins. If you plan to use groundwater in a confined feedlot with a capacity of more than 1,000 head of cattle or that uses more than 15 acre-feet of water per year for dairy cattle or confined livestock other than cattle, then you need to obtain a permit to appropriate water before constructing the facility. If you plan to water livestock in a pasture or in a confined feedlot with a capacity of less than 1,000 head of cattle, a water appropriation permit is not required because the uses are considered to be domestic.

http://www.ksda.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 work such as site development fills, causeways or road fills, dams and dikes, artificial islands, bank stabilization (riprap, seawalls and breakwaters) levees, landfills, fish attractors, mechanized clearing of wetlands, pipeline and cable crossings, grassed waterways, other channel modifications, and certain excavation 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 permit through Section 10 of the Rivers and Harbors Act. 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/regulatory/activities%20requiring%20permits%20fact%20sheet.pdf

(816) 839-3990 (Kansas City District)

Kansas Dept. of Health and Environment

Before a Corps of Engineers 404 permit is issued, a Section 401 "Water Quality Certification" is required from KDHE to verify that the project is in compliance with the state water quality standards. This permit is automatically filed when a Section 404 permit is requested. The certification must be issued by the state before the corps will issue its permit. The department makes a determination of the projected impact on water quality resulting from the proposed action and may approve the action, approve it with modifications, or deny the action based on projected water quality impacts.

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.

http://www.oznet.ksu.edu/library/h20ql2/mf2329.pdf

http://www.kdheks.gov/nps/resources/nwpwqppfrm.pdf

(785) 296-0075

Permits in Kansas

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 One-Call (1-800-DIG-SAFE)
"Kansas One-Call" is the underground utility notification center for the state of Kansas. Through this center a person can notify operators of underground facilities of a proposed excavation to request that member companies mark their underground facilities. If excavation activities accidentally sever optic fiber lines or other utilities, repair costs can be expensive. Call BEFORE you dig.

Kansas One-Call service promotes public safety, protects vital utility services and safeguards against property and environmental damage.

http://www.kansasonecall.com/

(800) 344-7233

Other Permits
Confined livestock require permits other than those listed above. For more information, review:

http://www.kdheks.gov/feedlots

Helpful Resources

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