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Rainwater Harvesting for Livestock Production Systems

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Introduction

Abundant, clean drinking water is essential for livestock. The obvious water source recommended by veterinarians is city water. However, city water has its drawbacks. City water distribution systems are often expensive to install and have a recurring usage charge. In some instances, city water is unavailable, may have inadequate pressure, or producers consider it too expensive to operate, forcing them to use streams and ponds to water livestock.

Collecting rainwater from a catchment area, is a low cost, high quality alternative water source that can supplement traditional water distribution systems and improve the environmental quality of farming operations. Rainwater harvesting involves the collection of rainfall from rooftops or land-based catchments systems for storage and distribution as needed (Figure 1). Capturing rainfall has the added benefit of improving water quality by reducing soil erosion and runoff. Strategically installed rainwater harvesting systems can be used to direct stormwater around sensitive areas of the farm where animal waste is present, thus reducing the potential for nutrient and pathogen delivery to nearby waterways. Rainwater harvesting and stormwater management techniques can also reduce the volume of water that must be managed in liquid manure management systems by diverting clean water away from manure pits and lagoons.

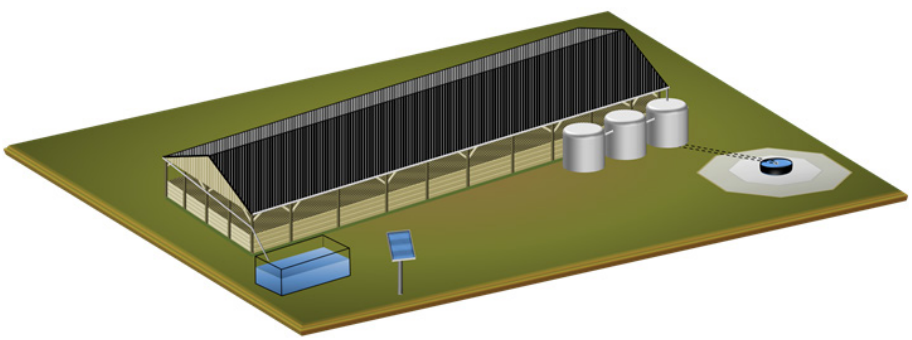

Figure 1. Rainwater harvesting for livestock production involves the collection of rainfall from rooftops or land-based catchments systems for storage and distribution as needed. Figure by Donnie Stamper

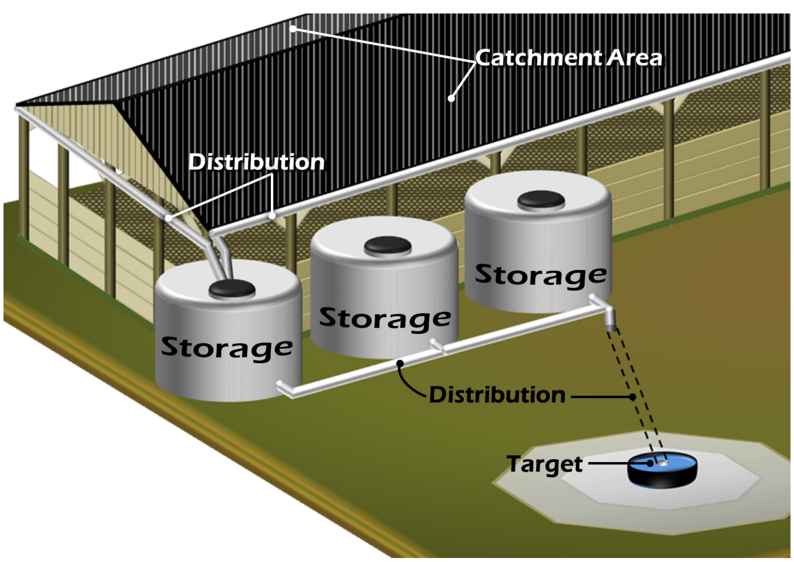

Figure 2. A basic design consists of a catchment area, distribution, storage, and a target. Figure by Donnie Stamper

Planning and Construction

The design of a rainwater harvesting system can be as unique as any farm. A complicated system is not needed for harvesting rainwater. A basic design consists of a catchment area, distribution lines, storage, and a target (Figure 2). Optimization of the system is accomplished by matching the size of the system to livestock water demand. The system operates using the hydrologic cycle. Approximately 95 percent of the total rainfall that lands on a roof (catchment area) can be harvested. Average monthly rainfall totals can be great resources for estimating the amount of rainfall available for harvest. Simple plumbing techniques allow distribution of water from the catchment area to the storage structure(s) and the target.

Water storage structures are the most expensive component of the system. Storage structures in a rainwater harvesting system may include tanks, cisterns, ponds, bladders, or a variety of other options. The storage volume can be equal to or slightly exceed the normal water demand between rainfall events, if the catchment area can provide it. The roof area can be measured manually in the field or by measuring orthorectified aerial images from a web- or desktop-based mapping application. The approximate roof area collected (measured in square feet) should be multiplied by 0.083 to determine the cubic feet of water volume generated by a 1-inch rainfall event. Cubic feet generated multiplied by 7.48 calculates the volume of water generated in gallons. Multiplying this value by the collection efficiency coefficient of 0.95 gives you a more accurate estimate of water collection capability, considering that it is never possible to collect 100 percent of the rainfall that hits a surface. The volume in gallons provides the producer an idea of how long livestock can utilize a specified area based on herd size and water requirements.

Example Calculation

Rainwater catchment estimate for 1-inch rainfall event

Step 1. Roof area (sq. ft.) x 0.083 ft. (1 inch) rainfall = cubic feet of water

Step 2. Cubic feet of water x 7.48 = gallons of water (if 100% of rainfall was collected)

Step 3. Gallons of water x 0.95 = maximum amount of water likely to be collected from a 1-inch rainfall event.

A Microsoft Excel workbook has been created and is available for download (https://www.uky.edu/bae/sites/www.uky.edu.bae/files/waterharvest.xlsx) to aid in sizing your water harvesting system based on the demand of your livestock and the catchment area available for collecting water. An instructional tab is provide within the workbook to provide guidance on use and interpretation of the water harvesting system–sizing tool.

The distribution system begins with the placement of a number of storage structures that have been calculated to be sufficient enough to meet your operation's demand. Plumb the downspouts directly into the storage structures using UV resistant pipe that is not going to deteriorate in the sun. Non-UV resistant PVC pipe can be used if it is coated with paint specifically for plastic, to protect it from ultraviolet rays. Adding gutter guards and a first flush diverter (Figure 4) into the system will reduce potential contamination prior to water entering the storage structures. Keeping contaminants out of the system can improve water quality and reduce the risk of pipe obstruction from debris. Water distribution from the storage structures is accomplished by using gravity or pumps.

Place storage tanks above the highest point of distribution to utilize a gravity flow watering system. For every foot of elevation change between the tank and waterer you gain 0.433 PSI of pressure. As water flows through a pipe pressure is lost due to friction. Check friction loss ratings of pipe and evaluate total pressure loss within the length of pipe used for connecting components. The pressure head from change in elevation minus the loss of pressure due to friction in pipes will provide you with an estimate of the total system pressure. Be sure to select a valve with an appropriate pressure rating for your system layout.

If gravity flow will not work for your system layout, incorporate a pump to lift water as necessary to areas of demand. There are many choices for pumps and multiple ways to incorporate them into your system. Determine the right pump for your distribution system by comparing the lift requirements and total friction loss (based on pipe diameter and length) of your layout and the demand for water at the various points of use with the performance curve of potential pumps. An electronic float switch can be incorporated into the system to control the pump. For livestock watering applications, the rate of fill needs to be equal to or greater than the projected demand to prevent waterers from going dry while in use. This is true for both pumped and gravity-fed systems. If a gravity-fed system cannot meet a given water demand, a pump should be incorporated to enhance flow rates. In situations where it is impossible to provide water at a rate equal to the consumption, increase the volume of the watering tank to allow for an additional reserve of fresh water during peak demand.

Considerations, Recommendations, and Specifications

You may download an Excel spreadsheet (https://www.uky.edu/bae/sites/www.uky.edu.bae/files/waterharvest.

Figure 3. A series of aboveground tanks that have been connected together to create one large storage system. Valves on the pipes coming out of the bottom of each tank allow tanks to be drained and managed individually, if necessary. A common overflow pipe plumbs overflow water from the tanks outside of the production area. Similar concepts may be applied to cisterns. Photo by Lee Moser

xlsx) to help you size and design your water harvesting system. The following sections provide brief recommendations and specifications associated with system design.

Types of Storage

Aboveground tanks

Use opaque tanks to control developing algal blooms in the tanks. Developing an enclosure around your tanks can help reduce environmental exposure and regulate temperature. Ensure that livestock are kept away from exposed pipes and fixtures to avoid damage. The foundation for the tanks needs to be able to support the weight of the tank and the weight of the water stored. Aboveground tanks are vulnerable to freezing and should be drained for the winter to avoid damage. Drain valves should be left open during the winter to keep water from standing in tanks and potentially freezing.

Belowground tanks (cisterns)

Cisterns are an excellent option for storing rainwater for livestock watering. Cisterns are pre-existing on many livestock operations and can potentially be incorporated into rainwater harvesting systems to reduce the cost of water storage structures. If existing cisterns are utilized for storage, it is critical that the water quality within the structure is evaluated to ensure that no issues exist prior to system design. In most situations, cisterns are more expensive to install than above ground tanks due to the cost of excavation. Installing new, underground cisterns can provide an opportunity to rework production areas and improve stormwater management systems. Underground cisterns can also be linked in series with the use of compression fittings, and an overflow pipe can be incorporated to safely divert any volume of rainwater that exceeds the capacity of the system away from the production area. Cisterns are more resistant to freezing than aboveground tanks.

Ponds

Ponds can be utilized to capture and store stormwater for livestock use. As with all ponds, fencing is recommended to exclude livestock from direct access. Restricting livestock access reduces the potential for introducing pathogens and nutrients into the storage pond. It is also important to ensure that herbicides, pesticides, and other chemicals are not introduced into the watershed area that drains into the pond. The water from ponds can be directly plumbed to a watering fixture through a gravity flow pipeline or with a siphon system. Pumps can be incorporated, if necessary. The most effective pond-fed waterer layout is a gravity flow waterer below the dam of the pond with fencing to keep livestock off of the dam and out of the pond.

Connections

Connect adjacent tanks and cisterns using a manifold system with valves. Incorporating valves between tanks allows for draining and maintenance of individual tanks without having to completely drain the system (Figure 3). Connect supply line from storage to waterer. Hybrid systems with city water connections can be used. City water and harvested water lines must be kept separate. It is critical that a back-flow preventer or double check valve is incorporated into any system where city water lines can come into contact with rainwater or water from livestock tanks. Follow basic plumbing specifications to prevent pipes from freezing (burial below the frost line for your location), or utilize the system during frost free period, then winterize. You should ensure that state and local plumbing codes are followed when utilizing city water for livestock. Anti-siphon air gaps may be a useful additional method for preventing backflow into city water lines in the event of loss of water pressure.

Pumps

Electric pumps using solar power (DC) or traditional electric motors (AC) can be used to pump water to waterer(s). Pumping capacity should be adequate to supply the drinking water rate (2 gallons per minute per animal), if the storage volume in the waterer is limited. A pump controller and float switch can be incorporated into the system to regulate pump activity.

Contamination

The drinking water quality guidelines for livestock consumption are similar to those for human consumption. When developing your rainfall harvesting system you should consider potential sources of contamination. Contamination can be present in the forms of bacteria, viruses, heavy metals, or other readily dissolvable contaminants that are present on the catchment surface. Some sources of catchment contamination include bird droppings, dust, leaves, silage, and the roofing material itself. These contaminants can also clog pipes and fittings within the system. Ideally, the catchment surface should be constructed using painted or coated surfaces. Producers should avoid systems that rely on rusty roof panels or panels that may be coated with lead based paint due to the high potential for iron and lead contamination. Do not collect water from a roof with asphalt shingles unless first flush diverters and baffled settling chambers are utilized. Incorporating leaf guards or gutter screens can aid in preventing debris from entering the system. For further information on water quality guidelines for livestock please see ID-170 (http://www2.ca.uky.edu/agcomm/pubs/id/id170/id170.pdf).

Producers can incorporate roof washing systems (screens over gutters and downspouts, baffled chambers, and a first flush diverter) into the plumbing system before water enters the holding tank(s) to reduce contamination (sediment, dust, pathogens, biological agents, etc.). First flush diverters (Figure 4) are chambers with a floating ball valve at the top that fill prior to the tank when the system collects water during a storm. You should size your first flush diverter to be one to two gallons per 100 square feet of catchment area. Once the first flush chamber is full, the floating ball valve closes and the tank begins to fill. The first flush diverter collects the majority of the contaminants that are present in the initial flush of water from the catchment surface. Empty the first flush diverter prior to the next storm to ensure the highest possible initial water quality within the system. A baffled chamber at the tank inlets can also help to slow down water and allow for further settling of solids before entering your tank and plumbing system. Reducing the amount of solids entering your system can reduce potential main-

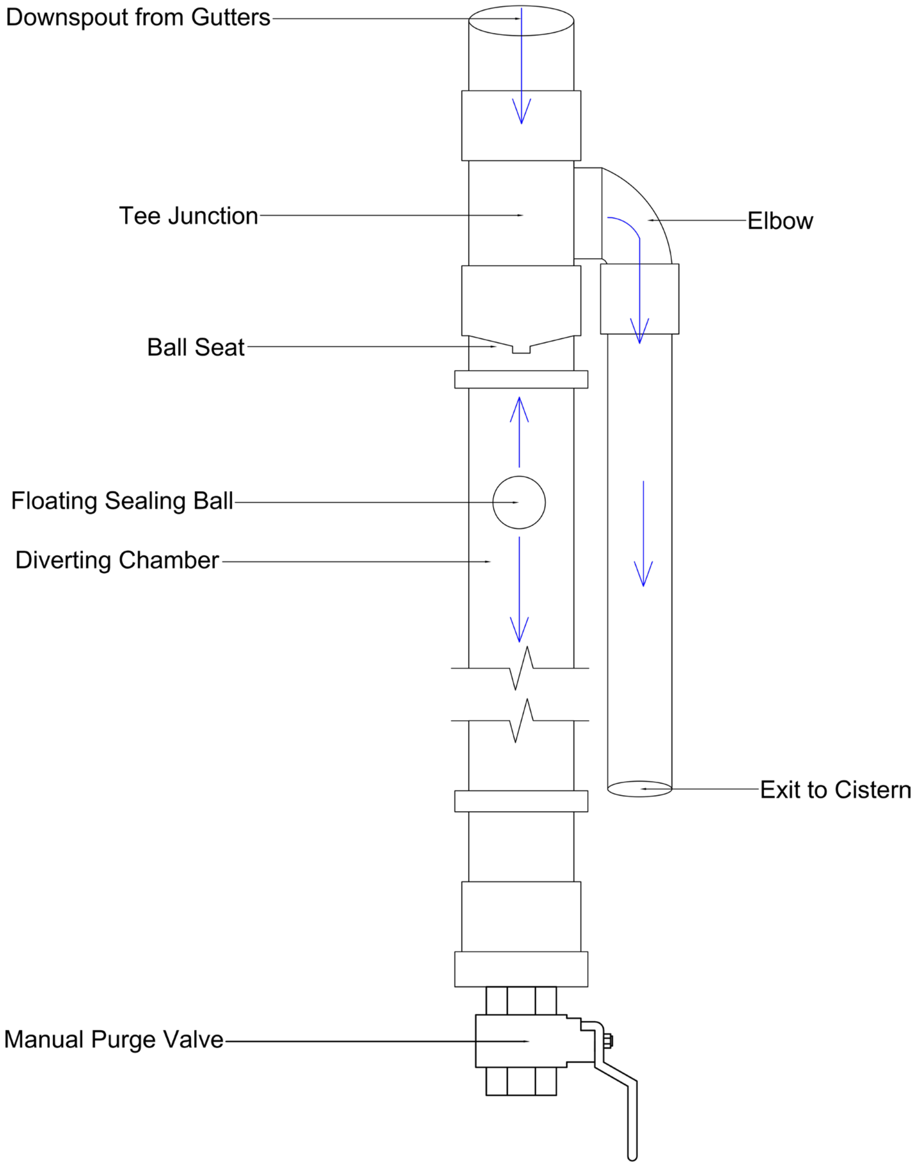

Figure 4. A flush diverter is a chamber with a floating ball valve at the top that fills prior to the main storage tank when the system collects water during a storm. The "first flush" is then purged to prevent contaminants from the initial roof wash from entering the main storage tank.
Figure by Ciara Pickering

tenance and extend the life of the system.

Algal Growth

Algal growth within a water harvesting system can become a potential source of contamination. Algae can also clog pipes, valves, and fittings. The key to dealing with algal growth is prevention. Primary methods of prevention include regular cleaning, reducing the input of nutrients into the system (in the form of feed, organic material, manure, fertilizer, etc.), and reducing the exposure of harvested water to sunlight.

If prevention proves ineffective, treatment with an algaecide is the next option. It is recommended that algae be identified prior to treatment. Several species of blue-green algae (cyanobacteria) can release toxic compounds during death and decomposition. Branched filamentous green algae should pose no risk of introducing secondary compounds from death and decomposition during treatment. Handle and apply all chemicals based on manufacturer recommended rates and guidelines presented on product's Material Safety Data Sheet (MSDS). Ensure that selected algaecides are safe for livestock consumption.

If algae identification cannot be confirmed or treatment is ineffective, one last option is to completely flush and clean the system; since the water that was collected was free, this is not a major loss. Time system flushes to occur prior to an anticipated rainfall events to allow for a quick refill of the system. Contact your county Cooperative Extension agent or local Conservation District with questions regarding algae control.

Maintenance

Perform periodic maintenance on your rainwater harvesting system to ensure proper function. Routine maintenance includes:

- Cleaning and maintaining gutters, screens, and filters
- Emptying first flush diverters and roof washers
- Cleaning tanks as necessary
- Maintaining pumps and hose lays
- Cleaning waterers for livestock use
- Monitoring for algal growth on a weekly basis and treat or release stored water as necessary.
- Annually testing water quality of harvested water based on guidance in UK extension publication, "Drinking Water Quality Guidelines for Cattle" (ID-170)
- Winterizing tanks and pipes by insulating or draining the system and opening all valves
- Ensuring "Not Potable Water" signage is affixed on tanks and readable
- Installing and maintaining fencing around water harvesting system to ensure equipment- and livestock-related contamination and damage are avoided

Summary

Rainwater harvesting can provide a high-quality, low cost alternative to traditional water resources for use at home or on the farm. Installation of a system reduces demand on potable water systems for applications where non-potable water will suffice. Implementing a rainwater harvesting system also provides water quality improvements by reducing runoff and delivery of contaminants.

For more information regarding rainwater harvesting at your home or farm please contact your local Conservation District or county Cooperative Extension office.

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