TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE — NATURAL RESOURCES CONSERVATION SERVICE
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RANGE TECHNICAL NOTE NO. 26

Hydraulic Ram Pumps

Livestock watering systems are used to aid in getting better animal distribution within a range unit or pasture. Many of these systems use springs and gravity or wells and pumps to get water into troughs. Creeks and streams and ponds are often used where they are located to provide water on site. Research has shown that livestock perform better with water provided in a clean trough than when drinking directly from existing surface water sources. There is increasing pressure to limit the use of surface water sources for livestock use. Hydraulic ram pumps can be used to provide water away from the flowing stream or creek, while improving animal performance and limiting environmental concerns. Hydraulic ram pumps are well adapted to locations where other power sources are limited. They do not need any electricity, can work anytime the stream is flowing, and do not need wind or sunshine to operate.

This technology note is designed to provide the history of ram pumps, describe how they work, and be a general guide to applicability. Site specific designs need to be completed under the supervision of a licensed engineer. This technology note does not provide enough specific information to complete such a design but does indicate the types of information needed to complete the site specific design.

History

Hydraulic Ram Pump technology has been around since the late 1700's. The first record is found in England in 1772 for a precursor to the ram pumps of today. This earlier pump was called a "pulsation engine" and was designed by Edward Mangino of Cheshire, England.

The first record of an actual ram pump is from France in 1796. Joseph Montgolfier added some valves and thus automated the earlier pulsation engine. This pump was patented in England in 1797 and improved in 1816.

The first United States patent for ram pumps was issued in 1809 to J. Cerneau and S.S. Hallet.

Interest in ram pumps continued throughout most of the 19th century as more patents were issued in the United States and the French design and British patent were acquired by Josiah Easton of London, England.

In the United States, interest in ram pumps declined in the 1890's as electricity and electric pumps became more widely available.

Today, ram pumps are installed and functioning worldwide.

General Functioning Principles

The basic principle behind ram pumps is to use a large amount of water falling a short distance to pump a small amount of water to a higher elevation. Typically, only 2% to 20% of the water flowing through a ram pump system will actually be delivered to the storage tank or trough. The remainder is overflow and directed back into the stream.

Limitations

- Plastic pumps are limited to very low delivery heads
- Output head (approx. equivalent to height) is usually 5-25 times the input head (approx. equivalent to fall)
- Pump efficiency
  - Usually 50% to 60%
  - May be as high as 80%
  - May be less than 40%

The amount of water delivered to the end use will depend on

Source flow

Height of supply reservoir above pump

Height of delivery site above pump

Length and size of delivery pipe and drive line

Pump efficiency

Size of pump

Given all these variables, the amount of water delivered with a single 2" ram pump system can range from a low of 17 gallons per day to 4,000 gallons per day or more.

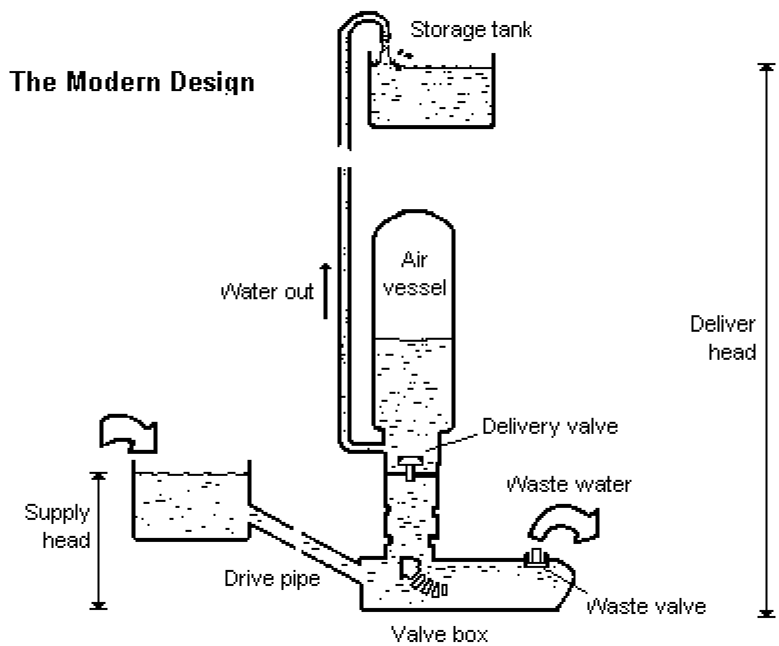
Can you use a ram pump in your situation? Here are some minimum guidelines to help answer that question.

Site Characteristics	**Recommended Minimums**
Stream Flow	8 gallons per minute (0.018 cfs)
Stream Gradient	2 percent (2 feet fall in 100 feet reach)
Supply Fall or Head	6.6 feet (from supply reservoir to pump)

Sites with characteristics less than the recommended minimums listed may be able to run a ram pump, but may require more diligent maintenance and monitoring to maintain constant flows.

- Ram Pumps

So, how do ram pumps work?



Water flows from the supply reservoir down the drive pipe into the valve box. Initially, the waste valve is open and allows water to flow through it and back into the stream. As the water flow increases, it causes the waste valve to quickly close. The closing of the waste valve creates high pressure within the pump, also known as water hammer. This redirects the water past the delivery valve and out the supply line to the storage tank or trough. The water flow within the valve box rapidly slows, opening the waste valve and starting the cycle again.

Ram pumps have two main operating characteristics: lots of water flows out the waste valve, and there is a cyclic nature to the pumping action which is somewhat noisy.

How much pump is needed for some generic situations?

Assumptions

- 100 cows with calves
- 100 feet lift to storage tank
- Maximum water need for cows (30 gallons per day)

A 2-inch ram pump can supply 3000 gallons per day (2 gallons per minute) to a storage tank that is 75 feet higher than the pump using a drive line that is 2-inch diameter steel and 50 feet long from a supply reservoir located 10 feet higher than the pump. The stream flow required for this is at least 31.5 gallons per minute (0.07 cfs) (assuming a pump efficiency of 50%).

A 4-inch ram pump can deliver the same amount of water to a storage tank that is 245 feet higher than the pump using the same length of 4-inch diameter steel drive line. The stream flow required for this is at least 102 gallons per minute (0.23 cfs).

- High Lifter Pumps

Piston ram pumps are a variation of ram pump with a piston added. These pumps may work at lower flows and/or higher lifts than the typical ram pump. They are designed to be 2 to 4 times as efficient at delivering water as ram pumps.

Cost

The cost of installing hydraulic ram pumps needs to include all components of the system. These components include

Supply/settling reservoir

Drive line

Hydraulic ram pump (variable from several hundred dollars to several thousand dollars each depending on materials used, size, and design)

Pump base

Supply line

Storage tank

Trough(s)

Overflow pipelines

Labor and machinery used in the installation

Maintenance activities and costs should be included in the operational costs of the system.

Planning Procedure

The following items need to be considered prior to the selection of a hydraulic ram pump system.

- Resource Inventory – Information per Oregon Conservation Planning Procedure must be obtained when planning a hydraulic ram pump system (e.g. when will it be used, how many and what kinds of animals will use it, and where is the source located and where will the trough(s) be located).
- Planning map – sketch a plan map of the system with the following information noted: location of inlet storage tank for the drive line, location of pump station, location of water outlet storage tank, the distances between each location, and the

approximate elevation at each location. The elevations can be approximated with the aid of a Global Positioning System (GPS) device.

- System Available Input – determine the available water supply (S) in gallons per minute (gpm) and the fall elevation (F) between the flow inlet storage tank and pump station in feet. The water supply should be available for the duration of the water need period and flow at the same constant rate.
- System Required Output – calculate the livestock daily water usage (D) to determine minimum required rate of flow in gallons per day (gpd). Determine the lift elevation (L) between the pump station and flow outlet in feet. Use the following table to determine the maximum pumping rate in gpd.

Lift to Fall Ratio. *L/F* (ft/ft)	Maximum Pumping Rate, *Q* (gpd) Source Flow Rate, *S* (gpm)							
	2	5	10	15	20	30	50	100
2	864	2,160	4.320	6,480	8.640	12,960	21,600	43,200
3	576	1,440	2.880	4,320	5.760	8,640	14,400	28,800
4	432	1,080	2.160	3,240	4.320	6,480	10,800	21,600
5	346	864	1.728	2,592	3.456	5,184	8,640	17,280
6	288	720	1.440	2,160	2.880	4,320	7.200	14,400
7	247	617	1.234	1,851	2.469	3,703	6.171	12,343
8	216	540	1.080	1,620	2.160	3,240	5,400	10,800
9	192	480	960	1,440	1,920	2,880	4,800	9,600
10	173	432	864	1,296	1.728	2,592	4.320	8,640
12	144	360	720	1,080	1.440	2,160	3.600	7,200
14	123	309	617	926	1,234	1,851	3,086	6,171
16	108	270	540	810	1.080	1,620	2,700	5,400
18	96	240	480	720	960	1,440	2.400	4,800
20	86	216	432	648	864	1,296	2.160	4,320
25	69	173	346	518	691	1,037	1,728	3,456
30	58	144	288	432	576	864	1,440	2,880
35	49	123	247	370	494	741	1.234	2,469
40	43	108	216	324	432	648	1.080	2,160
45	38	96	192	288	384	576	960	1,920
50	35	86	173	259	346	518	864	1,728
60	29	72	144	216	288	432	720	1,440
70	25	62	123	185	247	370	617	1,234
80	22	54	108	162	216	324	540	1,080
90	19	48	96	144	192	288	480	960
100	17	43	86	130	173	259	432	864

NOTE: For L/F Ratio or Source Flow Rate > 100, use the following formula to calculate the Maximum Pumping Rate (MPR):

MPR = 1440 x (0.6 x S) / (L/F) gallons per day

- If the maximum pumping rate (MPR) meets or exceeds the required flow (D) then proceed with the pump design.
- Other consideration – Site selection criteria:
  - Pump and Storage Tank Location – they should be located at sites with good drainage to account for the waste water from the pump and overflow from the tank.
  - Flood consideration – the pump location should be located above the 100-yr flood zone.
  - Drive Pipe and Delivery Pipe Routing – the routes should be selected to minimize the number of high and low spots in the line.

Design and Installation Guidelines

The following factors need to be considered in hydraulic Ram pump system design.

- Intake design – a typical intake will be a stream diversion with a screen intake meeting Oregon Department of Fish and Wildlife fish screen criteria. The source of water supply shall not be an irrigation reservoir due to the limited volume for the pump operation. Water will be free of debris as well as sand and sediments. The flow rate will be used to determine the size of drive pipe.
- Drive pipe – must be made of non-flexible material for maximum efficiency and preferably the last 20 feet of pipe is galvanized iron or steel pipe. The length of drive pipe should be at least 5 times the vertical fall to ensure proper operation. Drive pipe diameter will be used to size the hydraulic ram pump.
- Pump – must be constructed above the 100-yr flood zone on a firm foundation. The pump must be mounted to a solid concrete base to account for vibration and water impact. All mounting studs, nuts and bolts must be stainless steel to prolong service life. Provide the following information to assist in sizing the system with the pump manufacturer:
  1. Available water supply in gpm _________
  2. Vertical fall in feet measured from the source water level to the foundation on which the ram pump will rest _________
  3. Distance from the water source to the ram pump in feet _________
  4. Vertical elevation lift in feet measured from the ram pump foundation to the highest point to which water is delivered ________
  5. Distance from the ram pump to the destination tank in feet _______
  6. Desired pumping flow rate to the destination tank in gpd _________
- Delivery pipe – minimized the distance and elevation to the storage tank to increase pumping rate. The delivery line can be made of flexible material such as HDPE pipe.
- Distribution system – the ram pump needs continuous flow of water. Hence no shut off valve shall be installed at the storage tank end of the line.

- System efficiency estimated by subtracting 6% from stated pump efficiency (use 50% if pump efficiency is not stated)
- Design Review and Approval – the design, installation, and start-up operation should be reviewed and supervised by a competent technician or engineer.

Maintenance

Since ram pumps use surface waters, they will require more regular maintenance than other water systems that use ground water. The water supply needs to be clean and free of debris. Any debris that restricts the operation of the valves will cause the pump to stop operation. Any blockage of the supply or delivery pipelines will also cause the pump to stop operation.

Although ram pumps have only 2 moving parts (the valves), there are significant pressures due to the “hammer” action. It is important to regularly check all connections and the pump for any signs of failure.

The following factors need to be considered in hydraulic ram pump system operation and maintenance.

- Winterizing – pipelines must be drained prior to freeze up.
- Intake – keep the inlet clear of all debris and sand at all time. In-stream water level should be check periodically to insure adequate water supply is continuously being delivered to the pump.
- Drive system – the pipe delivery route should be visually inspected once a year for breakage or leakage.
- Pump – all studs, nuts, and bolts should be inspected regularly for defects and all appurtenances checked for leakage or cracks. The pump must be removed at the end of the watering season and reinstalled at the start of the following season. Follow the manufacturer’s suggested maintenance schedule.
- Delivery pipes – the pipe delivery route should be visually inspected once a year for breakage or leakage.
- Outlet and storage tank – check area adjacent to tanks for signs of erosion from overflow water.

Other Concerns

As with other stream practice installations, the intake and outflow of ram pumps need to be screened to prevent fish or other material from entering the pumping system. This will also help reduce the maintenance needs of the installed system.

A clean water supply is important to the continued operation of ram pumps. Although ramp pumps have only two moving parts, it is vital to the pump operation that these parts operate as designed, i.e. the valves need to open and close completely, quickly, and without interference from water-borne material.

Do not plan a system that exceeds the water rights of the landowner. Doing so will put the landowner at risk of losing their water rights.

Direct the overflow from troughs and pumps back into the original stream wherever possible. Do not create wet areas that will have a negative impact on the site. Oregon water laws may require that the overflow from the pump be enclosed in a pipe and returned to the supply stream course.

It is recommended that ram pump systems be free flowing. Installing float valves in the delivery pipeline can cause the ram pump to cease operation due to excess back pressure on the ram pump. Float valves in troughs can be used if a storage cistern is installed between the ram pump and any trough and the cistern is open to the atmosphere.

Manufacturers

- Advanced Energy Solutions, Inc.
  192 Gates Road
  Pomona, IL 62975-2506
  http://www.advancedenergysolution.com/catalog/water/High%20Lifter%20Water-Powered%20Pumps%20-%20Water%20Pumping.htm

- Aquatic Eco-Systems
  2395 Apopka Blvd
  Apopka, FL 32703
  http://www.aquaticeco.com/index.cfm/fuseaction/product.detail/iid/8735/cid/2143

- CBG Enterprises
  A Carlson & Beauloye Co.
  2143 Newton Ave.
  San Diego CA 92113
  http://www.gravi-chek.com/

- The Ram Company
  512 Dillard Hill Road
  Lowesville, VA 22967
  800-227-8511
  http://www.theramcompany.com/index.html

- Glockemann Peck Engineering Pty Ltd
  P.O. Box 357
  West Ryde NSW 1685 Australia
  61-29-708-0900
  http://www.gpe-waterpumps.com/index.html
  - Imported to Canada by:
- Canuk Sales
  5178 Jeffries Rd.
  Duncan, BC Canada V9L 6S8

877-748-3048
http://www.canuksales.com/index.htm

- Rife Hydraulic Engine Mfg. Co. Inc.
  PO Box 95, Nanticoke, PA 18634
  570-740-1100
  http://www.riferam.com/rams/index.htm

Sources of information

- http://www.green-trust.org/2000/rampump.htm
- http://www.aces.edu/department/irrig/anr481.html
- http://www.engr.uga.edu/service/extension/publications/homeram.pdf
- http://www.eng.warwick.ac.uk/dtu/pubs/tr/lift/rptr13/rptr13.html
- http://www.agr.gc.ca/pfra/water/wpower_e.htm
- http://www.agf.gov.bc.ca/resmgmt/publist/Water.htm#pumping
- Jeffery, T.D., et al. 1992. Hydraulic Ram Pumps: A guide to ram pump water supply systems. ITDG Publishing, London