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Canada

WATER-POWERED WATER PUMPING SYSTEMS FOR LIVESTOCK WATERING

Producers fortunate enough to have a continuously-flowing source of water available may be able to harness the energy of the flowing water itself to convey water to a remote location where cattle can drink in comfort without impacting the source.

What kinds of water-powered pumps are there?

Prototype Floating Paddlewheel Pump

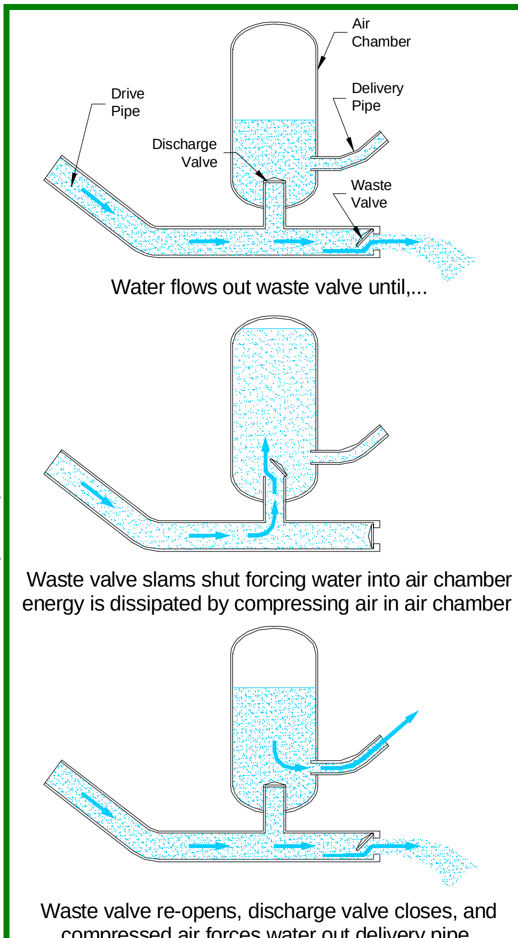
The power of flowing water can be harnessed through the use of water-wheels or turbines, and this power can be converted to electricity and stored to operate an electric motor which drives a standard pumping unit (diaphragm, positive displacement, centrifugal), or it can be used directly through a mechanical connection to a standard pump. PFRA is currently experimenting with a form of the latter configuration with a view to developing a stream-powered pumping unit that can be easily constructed using readily available materials and a minimum of fabrication effort and expertise. This initiative is still in the development stages and will be discussed in a separate fact sheet. This fact sheet will discuss two non-standard pumping units which use stream power (gravity) to propel water; the hydraulic ram and the sling pump.

Hydraulic Rams

The hydraulic ram harnesses the kinetic energy of water flowing down a pipe through the principle of water hammer, a phenomenon which audibly manifests itself as the banging heard in household plumbing when a tap is shut off quickly. Invented by Joseph-Michel Montgolfier (of hot-air balloon fame), the hydraulic ram has been in existence for about 200 years.

Initially, water flows from the source (usually a stream) through the *Drive Pipe* and out a *Waste Valve*. Water expelled through the *Waste Valve* is typically returned to the stream from which it was obtained. The flow through the *Waste Valve* increases until the drag of the flowing water on the *Waste Valve* overcomes the spring tension holding the *Waste Valve* open. At that point, the *Waste Valve* slams shut, resulting in a sudden increase in pressure in the *Drive Pipe*, forcing water through the *Discharge Valve* into the *Air Chamber*. The air in the *Air Chamber* is compressed and water is forced out the *Delivery Pipe*; the compressed air continues to force accumulated water from the *Air Chamber* out the delivery pipe.

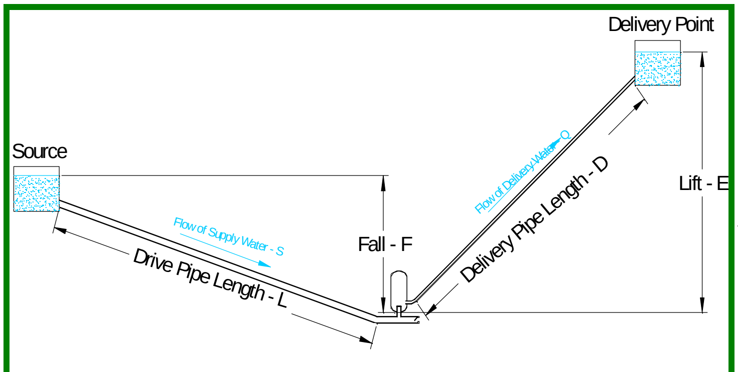
When the pressure in the *Drive Pipe* returns to static conditions, the *Waste Valve* re-opens and the cycle starts again. Once this cycle has been initiated, it will continue indefinitely, as long as there is a supply of water. Depending on the make and model of the pump, this cycle can occur up to 60 times per minute.



Hydraulic Ram Schematic

How much water can a Hydraulic Ram pump deliver?

The amount of water a hydraulic ram pump can deliver depends on the size of the components comprising the pump, and the layout of the system. The following sketch illustrates the salient features:



Hydraulic Ram Installation

The discharge that can be delivered to the delivery point can be approximated from the following equation:

$$Q = \frac{\eta SF}{E}$$

Where:
S = flow of supply water in the drive pipe (gpm)
Q = flow of delivery water (gpm)
F = vertical fall from the source to the pump (ft)
E = vertical lift from the pump to the delivery point (ft)
η = pump efficiency - varies, but averages 60% or 0.60

This relation is only applicable if certain criteria relating to system layout are met:

- the length of the drive pipe (L) must be between 5 and 10 times the fall (F). If site conditions are such that the length of the drive pipe must be greater than this, then an intermediate tank or open stand-pipe can be inserted the required distance away from the pump;
- the delivery lift (E) must be between 6 and 12 times the fall (F) to ensure that there is sufficient back pressure. If the delivery lift is less than this, back pressure can be created with a throttling valve or coils of pipe;
- the diameter of the drive pipe should always be larger than the diameter of the delivery pipe (roughly twice the size), and the length of the delivery pipe (L) should be between 150 and 1000 times the diameter of the drive pipe.
- the delivery pipe should consist of rigid material, preferably steel or possibly Schedule 40 PVC.

The following table lists typical sizes of hydraulic ram pumps and the approximate pumping characteristics.

Hydraulic Ram - Preliminary Sizing			
Pipe Diameter (inches)		Flow Rate (gpm)	
Drive Pipe	Delivery Pipe	Source - S (minimum)	Delivery - Q (maximum)
0.75	0.50	2.00	0.70
1.00	0.50	6.00	1.39
1.50	0.75	14.00	2.80
2.00	1.00	25.00	4.90
2.50	1.25	35.00	6.90
3.00	1.50	60.00	13.90
6.00	3.00	150.00	50.00


Hydraulic Ram in Operation
Source: http://dburger.tripod.com/

For example, consider a situation where it is desired to deliver water to a delivery point, about 80 ft. higher than the site where the pump would be located, at a rate of about 2.0 gpm. From the preceding table, for this situation, the delivery pipe should be about 0.75 inches in diameter, and the drive pipe should be about 1.5 inches in diameter. The fall from the source should be between 6 ft. and 13 ft., and the length of the drive pipe should be between 30 ft. and 130 ft. Assume then that the lay of the land is such that if the pump is placed at a distance of about 60 ft. from the source, a fall of 10 ft. is available. From the equation on the preceding page, in this situation, the flow available from the source should be at least 20 gpm.

Commercially manufactured hydraulic ram pumps can be purchased from a variety of manufacturers, but they can also be easily constructed with readily-available plumbing fittings, without the need for welding, tapping or any special tools. For additional information on how to construct a home-made hydraulic ram pump, there are a number of books available, as well as free sources of information on the Internet. Some of these are listed in the Sources of Information at the end of this fact sheet.

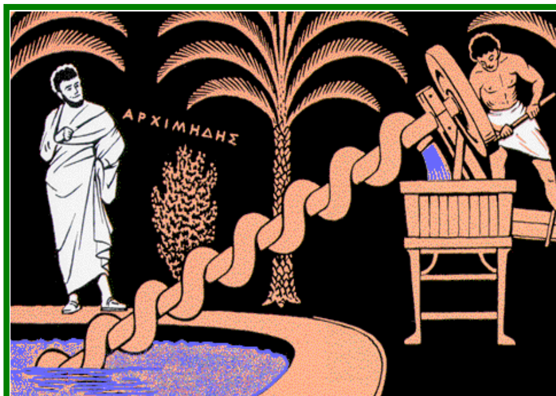
What other considerations are there with respect to Hydraulic Rams?

The inlet of the drive pipe should be fitted with a strainer to ensure that debris does not clog the system. The drive pipe should be as straight as possible, avoiding bends, and it should consist of rigid material that can withstand the pressures.

Hydraulic ram pumps are durable and economical, but their application is limited to situations where there is a continuous flow of water and topography that enables their use. Therefore, their use will probably be limited to the Rocky Mountain foothills or similar areas.

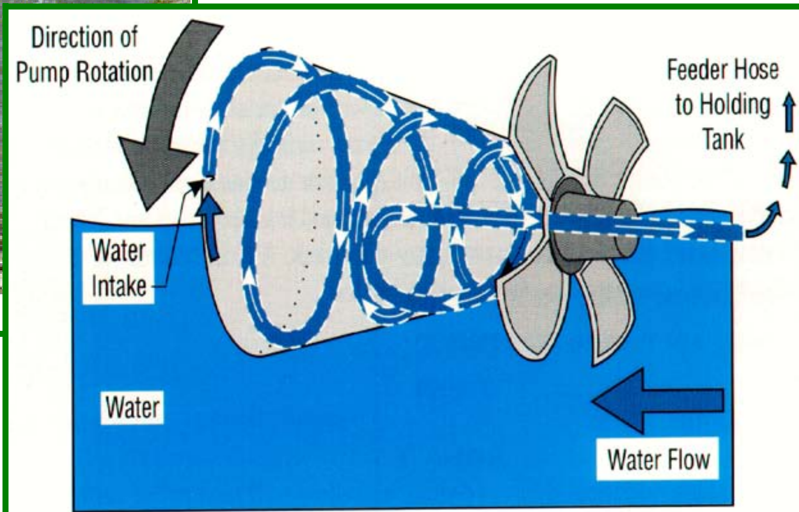
Sling Pumps

The sling pump is based on concepts even older than the hydraulic ram. Some 2000 years ago, Archimedes of Syracuse is credited with developing the basic concept of the sling pump in the form of the “snail”. While the original “snail” pump was operated by humans or animals, more recent applications have used the power of flowing water to turn the “snail”. A commercially manufactured form of the stream-powered Archimedes snail is the “slingpump”.



Archimedes Snail
From The Internet Glossary of Pumps
http://www.animatedsoftware.com/pumpglos/air_lift.htm

Sling Pump in Operation



Sling Pump - Schematic
From The Stockman’s Guide to Range Livestock Watering From Surface Water Sources

The commercially-available slingpump consists of a helically-wound hose within a drum-shaped body that has a propeller at the front. A swivel coupling at the front end of the pump allows the body of the pump to rotate freely without affecting the discharge pipe. Water flowing past the propeller at the front of the unit sets the entire body of the pump in a slow rotational motion. Alternating slugs of air and water enter the intake of the spiral hose and are forced along the pipe by the rotational motion of the pump. The slingpump can also be powered by the wind, instead of flowing water. Because the swivel coupling is the only mechanical component comprising the pump, it is virtually maintenance-free.

As an alternative to a commercially-available slingpump, it is possible to make such a unit. However, there does not appear to be much information on which to analytically base a design for such a unit, other than some fairly general statements such as those made in the following section.


From: *A Spiral Waterwheel Pump*, http://www.ata.org.au/65watwel.htm

How much water can a slingpump deliver?

The amount of water a slingpump can deliver, and the distance the water can be lifted, depends on: the number and diameter of coils comprising the unit, the diameter of the pipe comprising the coils, and the rotational speed of the unit, which will depend on the current of the stream. The following table lists performance data from one manufacturer:

Slingpump Performance Data			
Pump Model	1-16	2-16	2-20
Internal Diameter of Hose (in.)	0.5	0.5	0.625
Pumping Lift (ft.)	26	82	49
Required Depth of Flow (ft)	1	1.5	1.5
Discharge @ 2 ft/sec stream flow (gal/min)	0.57	0.73	1.1
Discharge @ 1.5 ft/sec stream flow (gal/min)	0.39	0.46	0.73
Dimensions (Diameter X Length, in)	21 X 34	25 X 54	25 X 54

Rife Hydraulic Engine Mfg. Co. Inc., PO Box 95, Nanticoke, PA 18634, Tel 570-740-1100 Fax 570-740-1101

What other considerations are there with respect to Slingpumps?

As with hydraulic rams, the use of slingpumps powered by flowing water is limited to situations where there is a continuously-flowing stream. There must also be sufficient depth to allow the unit to work. The current and the depth available in the stream can be altered through in-stream modifications such as constrictions or small weirs. However, any modification to a stream would require approval from Alberta Environment and Fisheries and Oceans Canada (refer to the fact sheet on Water Sources for Range Livestock in this series). Floating debris can hamper the performance of a slingpump, and it may be prudent to include a strainer on the inlet. Due to the limited discharge available from a slingpump, more than one unit may be required to meet the demands of a large herd.

Is there a requirement for water storage when using water-powered pumping units?

When using either a hydraulic ram or a slingpump, it is unlikely that water can be pumped at a rate sufficient to meet the peak water demands of the livestock to be watered. Also, either pumping unit, while fairly robust, has the potential to fail, and the water source will be subject to natural variations in availability. Therefore, water storage sufficient for three or four days demand should be used in conjunction with either pumping system. For additional information on water requirements, peak water use and water storage, consult the following fact sheets in this series: Water Requirements for Pastured Livestock; Troughs for Watering Range Livestock; Water Storage Facilities for Livestock Watering Systems.

The Bigger Picture

Water-powered water pumping systems are just one of many options available to producers interested in managing their rangelands, providing improved water quality for their livestock and protecting their water supplies. For additional information on other livestock watering systems, as well as solar-powered water pumping systems, contact your local PFRA office.

Sources of information for this Fact Sheet included: *The Stockman's Guide to Range Livestock Watering From Surface Water Sources*, available from the Prairie Agricultural Machinery Institute, P.O. Box 1060, 390 River Road, Portage la Prairie, Manitoba, R1N 3C5; *B.C. Livestock Watering Manual*, B.C. Ministry of Agriculture and Fisheries, Soils and Engineering Branch, Abbotsford, B.C.; *Hydraulic Ram Pumps*, Publication No. EBAE 161-92, North Carolina Cooperative Extension Service, *Home-made Hydraulic Ram Pump*, Clemson University Cooperative Extension Service, http://virtual.clemson.edu/groups/irrig/Equip/ram.htm, .*HYDRAULIC RAM PUMPS - A guide to ram pump water supply systems* T. D. Jeffrey, T H Thomas, A V Smith, P B Glover and P D Fountain; *All About Hydraulic Ram Pumps - How and Where They Work* (ISBN 0-96315626-2-9)

UNIT ABBREVIATIONS

psi - pounds per square inch	kPa - kilopascal	gpm - US gallon per minute
mm - millimetre	m - metre	ft - feet
in - inches	km - kilometre	L/s - litres per second

UNIT CONVERSIONS

1 US gallon = 3.785 litres	1 cubic metre (m^3) = 1,000 litres	1 metre (m) = 3.28 feet
1 Imp. Gallon = 4.546 litres	1 kilometre = 1,000 m = 0.62 miles	1 psi = 6.985 kPa
1 inch = 25.4 mm	1 psi = 2.307 ft. of water	1Hp = 746 Watts