Water for the World

Designing a Hydraulic Ram Pump

Technical Note No. RWS. 4.D.5

A hydraulic ram or impulse pump is a device which uses the energy of falling water to lift a lesser amount of water to a higher elevation than the source. See figure 1. There are only two moving parts, thus there is little to wear out. Hydraulic rams are relatively economical to purchase and install. One can be built with detailed plans and if properly installed, they will give many trouble-free years of service with no pumping costs. For these reasons, the hydraulic ram is an attractive solution where a large gravity flow exists. A ram should be considered when there is a source that can provide at least seven times more water than the ram is to pump and the water is, or can be made, free of trash and sand. There must be a site for the ram at least 0.5m below the water source and water must be needed at a level higher than the source.

Factors in Design

Before a ram can be selected, several design factors must be known. These are shown in Figure 1 and include:

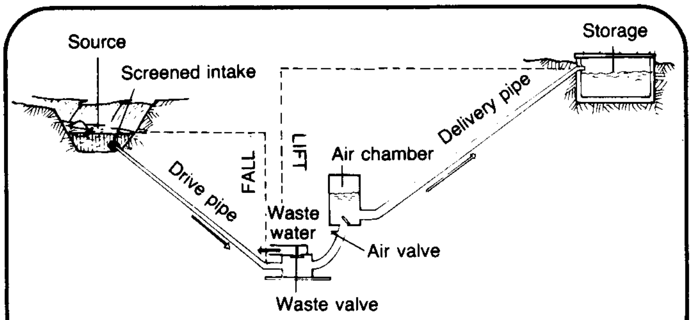

Figure 1. Hydraulic Ram Pump

1. The difference in height between the water source and the pump site (called vertical fall).

2. The difference in height between the pump site and the point of storage or use (lift).

3. The quantity (Q) of flow available from the source.

4. The quantity of water required.

5. The length of pipe from the source to the pump site (called the drive pipe).

6. The length of pipe from the pump to the storage site (called the delivery pipe).

Once this information has been obtained, a calculation can be made to see if the amount of water needed can be supplied by a ram. The formula is:

$$D = \frac{S \times F \times e}{L}$$

Where:

- D = amount delivered in liters per 24 hours
- S = quantity of water supplied in liters per minute
- F = the fall or height of the source above the ram in meters
- e = the efficiency of the ram (for commerical models use .66, for home built use .33 unless otherwise indicated)
- L = the lift height of the point of use above the ram in meters

Table 1 solves this formula for rams with efficiencies of 66 percent, a supply of 1 liter per minute, and with the working fall and lift shown in the table. For supplies greater than 1 liter/minute, simply multiply by the number of liters supplied.

Components of Hydraulic Ram

A hydraulic ram installation consists of a supply, a drive pipe, the ram, a supply line and usually a storage tank. These are shown in Figure 1. Each of these component parts is discussed below:

Table 1. Ram Performance Data for a Supply of 1 liter/mintue Liters Delivered Over 24 Hours

Working Fall (meters)	Lift - Vertical height to which water is raised above the ram (meters)											
	5	7.5	10	15	20	30	40	50	60	80	100	125
1.0	144	77	65	33	29	19.5	12.5					
1.5		135	96.5	70	54	36	19	15				
2.0		220	156	105	79	53	33	25	19.5	12.5		
2.5		280	200	125	100	66	40.5	32.5	24	15.5	12	
3.0			260	180	130	87	65	51	40	27	17.5	12
3.5				215	150	100	75	60	46	31.5	20	14
4.0				255	173	115	86	69	53	36	23	16
5.0				310	236	155	118	94	71.5	50	36	23
6.0					282	185	140	112	93.5	64.5	47.5	34.5
7.0						216	163	130	109	82	60	48
8.0							187	149	125	94	69	55
9.0							212	168	140	105	84	62
10.0							245	187	156	117	93	69
12.0							295	225	187	140	113	83
14.0								265	218	167	132	97
16.0									250	187	150	110
18.0									280	210	169	124
20.0										237	188	140

Supply. The intake must be designed to keep trash and sand out of the supply since these can plug up the ram. If the water is not naturally free of these materials, the intake should be screened or a settling basin provided. When the source is remote from the ram site, the supply line can be designed to conduct the water to a drive pipe as shown in Figure 2. The supply line, if needed, should be at least one pipe diameter larger than the drive pipe.

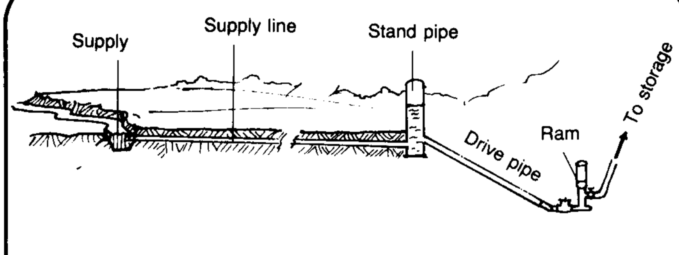

Figure 2. Ram Pump Remote from Source

Drive pipe. The drive pipe must be made of a non-flexible material for maximum efficiency. This is usually galvanized iron pipe, although other materials cased in concrete will work. In order to reduce head loss due to friction, the length of the pipe divided by the diameter of the pipe should be within the range of 150-1000. Table 2 shows the minimum and maximum pipe lengths for various pipe sizes.

Table 2. Range of Drive Pipe Lengths for Various Pipe Diameters

	Length	
Drive Pipe Size (mm)	Minimum (m)	Maximum (m)
13	2	13
20	3	20
25	4	25
30	4.5	30
40	6	40
50	7.5	50
80	12	80
100	15	100

The drive pipe diameter is usually chosen based on the size of the ram and the manufacturer's recommendations as shown in Table 3. The length is four to six times the vertical fall.

Table 3. Drive Pipe Diameters by Hydram Manufacturer's Size Number

Hydram Size	1	2	3	3½	4	5	6
Pipe Size (mm)	32	38	51	63.5	76	101	127

Ram. Rams can be constructed using commercially available check valves or by fabricating check valves. They are also available as manufactured units in various sizes and pumping capacities. Rams can be used in tandem to pump water if one ram is not large enough to supply the need. Each ram must have its own drive pipe, but all can pump through a common delivery pipe as shown in Figure 3. In installing the ram, it is important that it be level, securely attached to an immovable base, preferably concrete, and that the waste-water be drained away. The pump cannot operate when submerged. Since the ram usually operates on a 24-hour basis the size can be determined for delivery over a 24-hour period. Table 4 shows hydraulic ram capacities for one manufacturer's Hydrams.

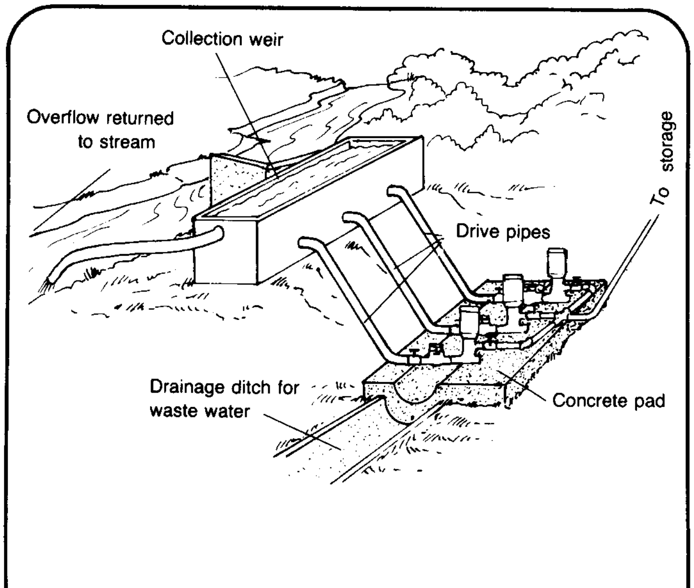

Figure 3. Multiple Rams with Common Delivery Pipe

Table 4. Hydram Capacity by Manufacturer's Size Number

		Size of Hydram								
		1	2	3	3½	4	5X	6X	5Y	6Y
Volume of Driving Water Required (liters per minute)	From	7	12	27	45	68	136	180	136	180
	To	16	25	55	96	137	270	410	270	410
Maximum Height to which Hydram will Pump Water (meters)		150	150	120	120	120	105	105	105	

Delivery Pipe. The delivery pipe can be of any material that can withstand the water pressure. The size of the line can be estimated using Table 5.

Table 5. Sizing the Delivery Pipe

Delivery Pipe size (mm)	Flow (liters/minute)
30	6-36
40	37-60
50	61-90
80	91-234
100	235-360

Storage Tank. This is located at a level to provide water to the point of use. The size is based on the maximum demand per day.

Sizing a Hydraulic Ram

A small community consists of 10 homes with a total of 60 people. There is a spring 10m lower than the village which drains to a wash which is 15m below the spring. The spring produces 30000 liters of water per day. There is a location for a ram on the bank of the wash. This site is 5m higher than the wash and 35m from the spring. A public standpost is planned for the village 200m from the ram site. The lift required to the top of the storage tank is 23m. The following are the steps in design.

Identify the necessary design factors:

1. Vertical fall is 10m.

2. Lift is 23m to top of storage tank.

3. Quantity of flow available equals 30000 liters per day divided by 1440 minutes per day or $\frac{30000}{1440}$ = 20.8 liters per minute.

4. The quantity of water required assuming 40 liters per day per person as maximum use is 60 people x 40 liters per day = 2400 liters per day.

$$\frac{2400}{1440} = 1.66 \text{ liters per minute (use 2 liters per minute)}$$

5. The length of the drive pipe is 35m.

6. The length of the delivery pipe is 200m.

The above data can be used to size the system. Using Table 1, for a fall of 10m and a lift of 80m, 117 liters can be pumped a day for each liter per minute supplied. Since 2400 liters per day is required, the number of liters per minute needed can be found by dividing 2400 by 117:

$$\frac{2400}{117} = 20.5 \text{ liters per minute supply required.}$$

From item 3 above, the supply available is 20.8 liters per minute so the source is sufficient.

Table 3 can now be used to select a ram size. The volume of driving water or supply needed is 20.5 liters per minute. From Table 4, a No. 2 Hydram requires from 12-25 liters per minute. A No. 2 Hydram can lift water to a maximum height of 250m according to Table 4. This will be adequate since the lift to the top of the storage tank is 23m. Thus, a No. 2 Hydram would be selected.

Table 3 shows that for a No. 2 Hydram, the minimum drive pipe diameter is 38mm. Table 2 indicates that the minimum and maximum length for a 40mm pipe the closest size to 38 is 6m-40m. Since the spring is 35m away, the length is all right. Table 5 can be used to select a delivery pipe 30mm in diameter which fits the supply needed, 20.5 liters per minute.

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U.S. Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association. Artwork was done by Redwing Art Service. Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations. For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the series, titled "Using 'Water for the World' Technical Notes." Other parts of the "Water for the World" series include a comprehensive Program Manual and several Policy Perspectives. Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D.C., 20523, U.S.A.

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