A RAM PUMP DEMONSTRATION

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*Water and Energy Research
Institute
of the
Western Pacific*

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INTRODUCTION

Pohnpei is located roughly at 7° north latitude and 158° east longitude in the Eastern Caroline Islands. The island is roughly circular with a diameter of 10 miles and an area of 144 square miles. The annual rainfall, recorded at Kolonia, is approximately 192 inches, with rainfall in the interior mountains ranging between 350 and 400 inches. Major drainage systems occur in the municipalities of Metalanim and Net with small rivers and intermittent streams being common in the remaining municipalities of Uh, Kolonia, Sokehs, and Kitti.

As one would expect, river and streams on Pohnpei play an important role as water sources in rural homes where there are no central water supply systems. They are traditionally used for bathing, washing clothing and dishes, and sometimes for drinking and cooking. On Pohnpei, many homes are located inland, sometimes at a significant distance from a river or stream and sometimes at a higher elevation than the nearest point on the river or stream. This can mean a long walk, frequently with a heavy load of clothing or an awkward load of cooking ware or, alternatively, the portage of water from the river or stream to the home.

A solution to this type of problem is pumping water from the river to the point of use. In cases where there is no power available and there is a surplus of water, the use of a hydraulic ram pump deserves serious consideration. A ram pump has a further feature for remote areas in that it only requires occasional simple maintenance. In many cases, a ram pump provides a sensible approach to pumping even when power is available. Unfortunately, very few ram pumps have been installed in Micronesia.

OBJECTIVE

The objective of this project was to install a hydraulic ram pump at an appropriate site in Micronesia as a demonstration. Its installation and operation would be documented so that other people with similar water supply problems might be able to duplicate the process. Primarily because of budgetary limitations, a small pump would be installed to serve an individual home or cluster of homes.

PRINCIPLE OF OPERATION

The usual elements of a ram pump installation are shown in Figure 1. They include a dam which impounds water in a river or stream or a suitable arrangement for capturing water from a spring. The water is then conveyed to a feed tank via a supply pipe and from the feed tank via a straight run of pipe (the drive pipe) to the ram pump. Wastewater from the ram pump is generally directed back to the stream or other convenient location. Water delivered by the ram pump is conveyed by the delivery pipe to a storage tank from which it is distributed to the home that will use the water. The performance of the ram pump depends on the volume of water entering it via the drive pipe and the ratio of the fall from the feed tank to the ram pump to the rise from the ram pump to the storage tank.
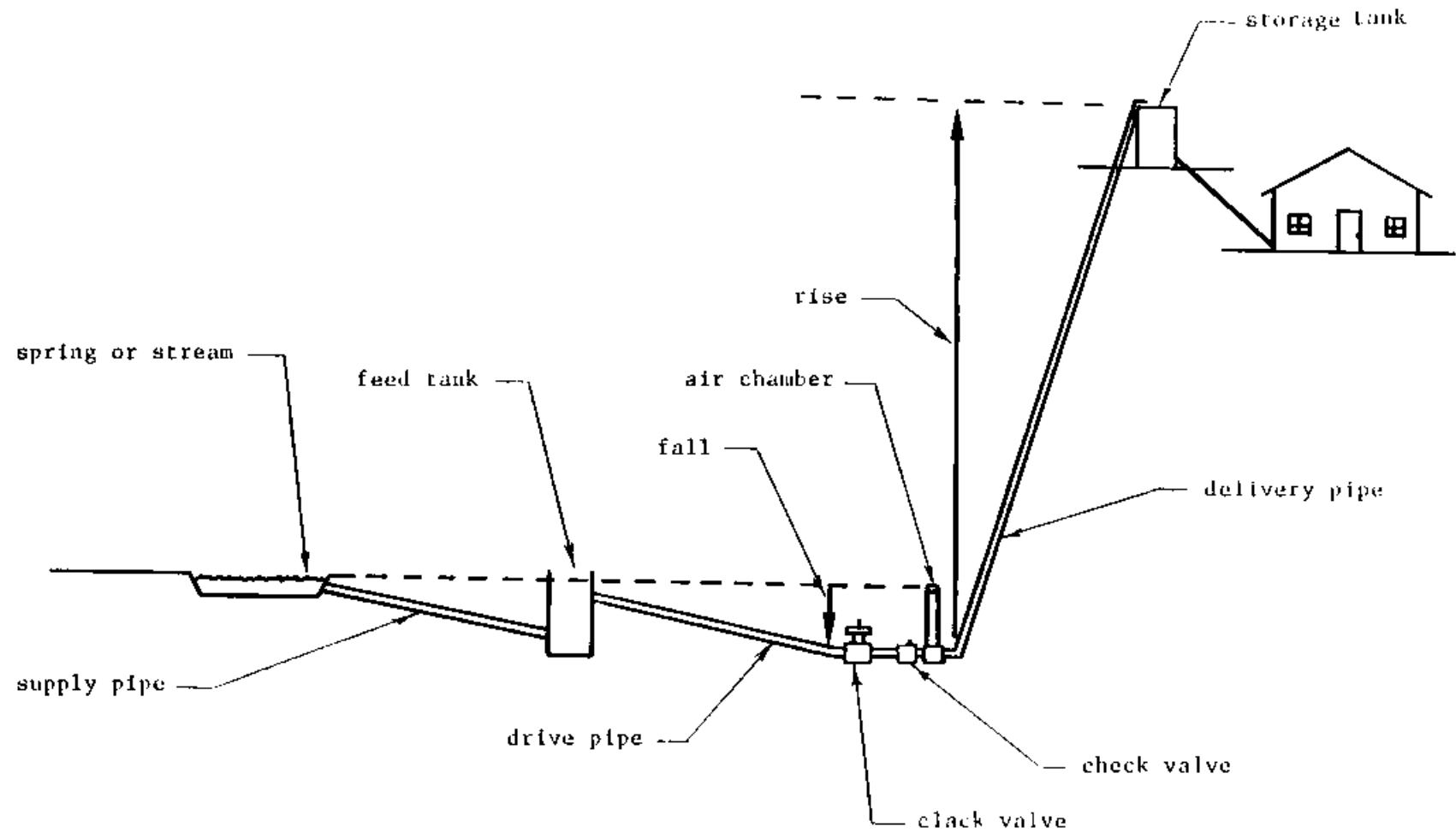
Figure 1. Schematic of a ram pump installation (adapted from D & P Manufacturing brochure).

The principle of operation of a ram pump (Figure 2) is simple. Water is allowed to flow with considerable force and speed down the inclined drive pipe into the ram pump. The water spills out through the clack valve until the pressure on the valve causes it to close. The water flows on through the pump body through the check valve and into the air chamber. The air within the chamber absorbs the momentum of the water until the pressures reverse in the form of a shock wave. This travels back through the water, causing the check valve to close. The water trapped in the air chamber is pushed out through the delivery pipe and into the storage tank. The clack valve and check valve then reopen and the complete cycle repeats once again.

SITE SELECTION

At the outset of the project it was decided that the demonstration would take place in Pohnpei because of the high probability of finding a suitable site there. Upon the recommendation of the Director, Department of Community Services, a site was selected in Ipwal Village in Sokehs Municipality near a private residence. The pump would serve this residence.

The project site is a spring-fed stream approximately 400 feet from the residence. The stream is approximately 100 feet long before dropping off a fall of around 40 feet. The stream is rocky immediately upstream of the fall and a dam site was selected at a natural narrow spot with shear rocky sides. The ram pump site was situated approximately 30 feet downstream at the bank of the stream adjacent to an area traditionally used for clothes washing (Figure 3). The fall from the dam site to the ram pump site was estimated at approximately 4 feet, the rise from the ram pump to the home at approximately 30 feet. A feed tank was not used, the impoundment of water behind the dam serving this purpose.

INSTALLATION

Two structures were built in order to complete the demonstration project: a pedestal to support the ram pump and a dam. Both were constructed of mortar and rock, the latter being abundant at the project site.

The pedestal was built adjacent to a large rock at the stream bank and fixed to it with no. 3 rebar, the logic being that the massiveness of the rock would make the pedestal immovable. Since the stream is primarily spring fed, there was less than usual hazard of floods washing out the installation. Most of the pedestal was constructed of rock and mortar. The top face was poured in forms which were leveled and into which mounting brackets for the ram pump were placed.

The dam was constructed by first diverting most of the stream flow around the dam site. This was accomplished by means of a siphon and a diversion ditch. A small quantity of water still seeped into the dam site. By fixing a PVC drain pipe into a plastic sheet with PVC cement and placing the sheet close to the bottom of the dam site, almost all remaining water

clack valve

check valve

air chamber

drive pipe

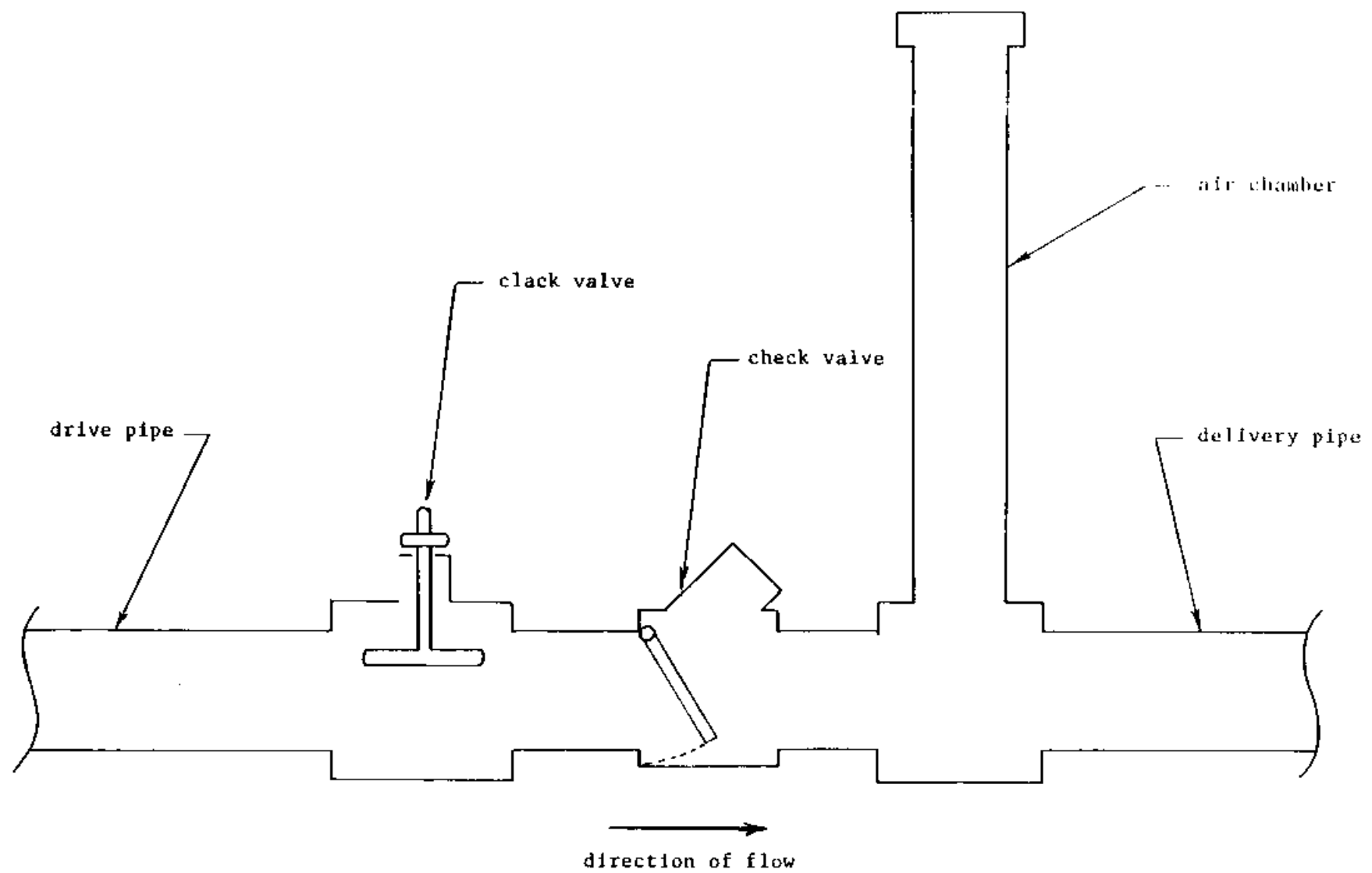delivery pipe

direction of flow

Figure 2. Schematic of "Hercules" ram pump.

Figure 3. Project site. Man is standing on rock where ram pump was
installed.

could be diverted through the pipe. It was then possible to pour mortar on the stream bed and begin to lay up the mortar/rock dam (Figure 4).

A Hercules Ram Pump by D & P Manufacturing was selected for this application because of its low cost (around $200) and because most of the pump components are standard pipe fittings. It was anchored to the pedestal in two places: by means of a clamp over the end of the drive pipe and by means of a bracket attached to the air chamber (Figure 5). The installation and operation instructions for the ram pump are reproduced in full in the Appendix.

A 1½ inch drive pipe was used (Figure 6), the maximum size recommended by the manufacturer. A 4 feet section of galvanized pipe was imbedded in the dam. The remaining run to the ram pump was PVC. Even though the manufacturer recommended a steel drive pipe, PVC was used in order to simplify construction since the pipe can be easily bent to correct for minor misalignment of the ram pump. It was believed that, since the fall was not too great, the vibration of the pipe would be small or insignificant. This turned out to be the case. The installed length of the drive pipe was 33 feet.

A ½ inch delivery pipe was used (Figure 7). This is smaller than the minimum (1 inch) recommended by the manufacturer. However, ½ inch was used to minimize expense and because flow rates of no greater than 1 gpm were expected. For the length of drive pipe used at this flow rate, the head loss would only be around 4 feet. PVC was again used in order to simplify assembly.

As installed, the fall from the free surface of the water behind the dam to the center line of the ram pump is 4.5 feet. The rise from the ram pump to the point where the pump was tested (flow rates measured) is approximately 30 feet. The rise to the anticipated point of use of the water is expected to be around 36 feet. This was simulated during testing by elevating the pipe 6 feet above the ground. The length of run of the delivery pipe from the pump to the test point is 420 feet. The length to the anticipated point of use is expected to be around 500 feet.

It was originally planned that a second pipe would be placed in the dam above the drive pipe to serve as a source of water for the traditional washing area. However, this pipe was broken loose from the dam (probably by children playing) within 24 hours of the dam construction. Consequently, it was decided to omit this pipe and make other undetermined future arrangements for providing a convenient water supply for this area.

TESTING

The ram pump installation was tested by noting the performance (flow rate at the end of the delivery pipe) (Figure 8) for different settings of the clack valve. The rate was noted for two different lifts, 30 feet and 36 feet, the latter corresponding to the elevation at the expected point of use. Also noted was the number of strokes per minute of the clack valve.
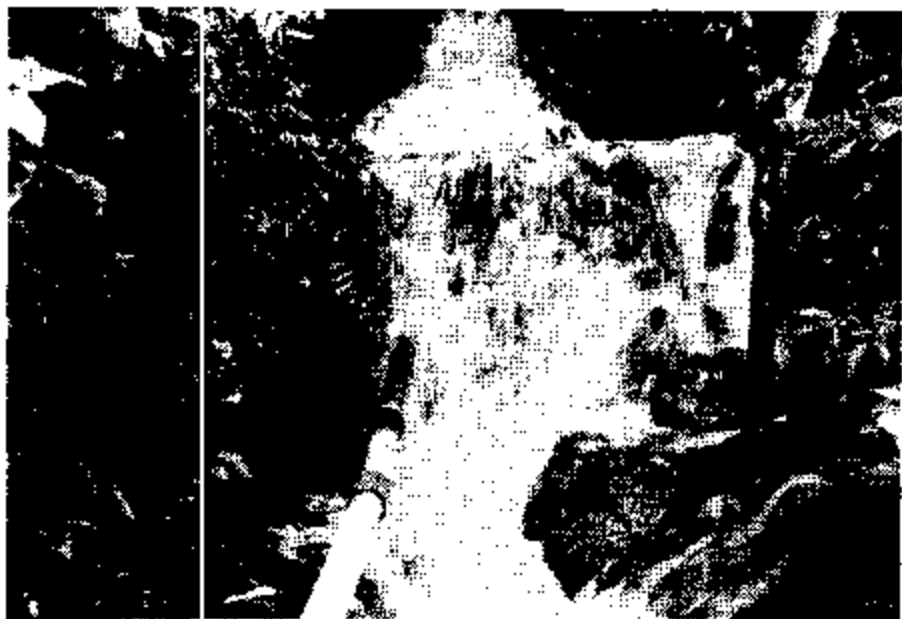
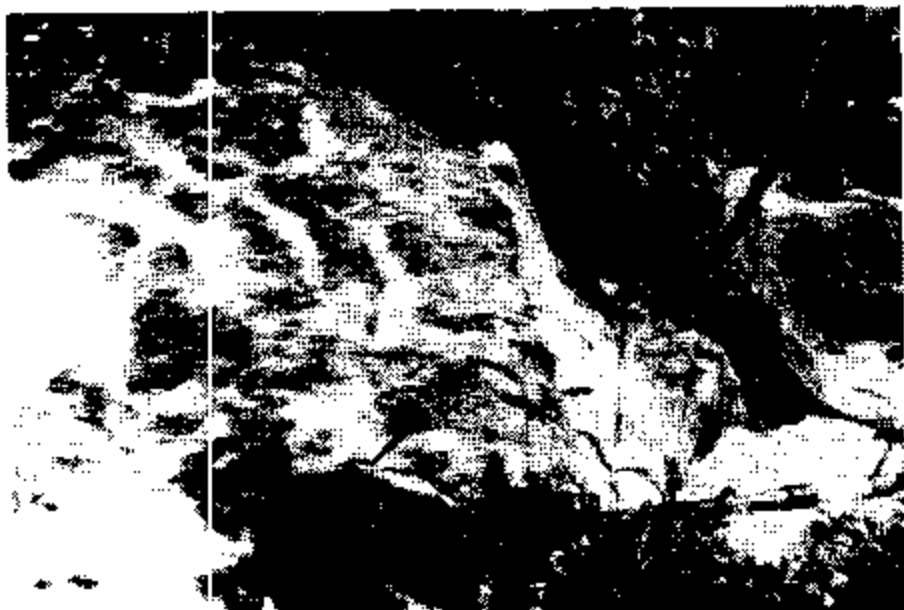Figure 4a.   The dam (viewed from the front).

Figure 4b.   The dam (viewed from above).

Figure 5. The ram pump installation. Note water being discharged from the clack valve.

Figure 6. The completed project. Note top of dam in center background.

Figure 7. The delivery pipe run.

Figure 8. Measuring flow from the delivery pipe.

The results of the performance testing are summarized in Table 1 and Figure 9. A few general observations can be made, all of which correspond fairly well with the manufacturer's prediction of performance. Firstly, the larger the setting of the clack valve, the lower the number of its strokes per minute. Generally speaking, the lower the strokes per minute (and the more water that is wasted through the valve), the more water will be pumped through the delivery pipe. However, at the largest setting of the clack valve for which the pump would function, the flow decreased somewhat. This is probably because the pump was barely functioning at that setting; it appeared that the water pressure was barely sufficient to close the clack valve.

For this installation, the flow rate at 30 feet elevation reached a maximum of around .85 gpm at a clack valve setting of anywhere from ½ to 3/4 inch. The flow rate at 36 feet reached a maximum of around .69 gpm at a clack valve setting from 5/8 to 3/4 inch.

In general, in order to reduce wear on the clack valve, it is always desirable to use the smallest setting of the stroke that is possible. For household applications it is emphasized that a low flow rate from the delivery pipe will still result in a large volume of water delivered over a 24 hour period. For example, a flow rate of only ¼ gpm will produce 360 gallons per day, an amount that may be adequate for all household water needs.

The Hercules ram pump is designed to function with between 1½ and 15 gpm of water supplied at the drive pipe. In this particular demonstration project, a supply far in excess of the maximum amount was available. Consequently, during the tests, water was always spilling over the dam. The formula given by the manufacturer for calculating flow from the delivery pipe is:

$$gpm = \frac{.6 \ FV}{R}$$

where: F = fall
R = rise
V = volume (gpm)

For this application, an estimate of the maximum gpm one could expect to be delivered at a 30 foot rise would be:

$$gpm = \frac{.6 \ (4.5)(15)}{34} = 1.19$$

where: 4.5 feet is the fall
34 feet is the rise (including an estimated 4 feet head loss in the delivery pipe)
15 gpm is the maximum expected flow that the drive pipe can transmit

The maximum flow that was measured at this rise was .85 gpm. This was lower than, but reasonably close to, the theoretically predicted value. The difference may be due to inaccuracies in measuring the rise (done with

Table 1. Ram pump performance test data.

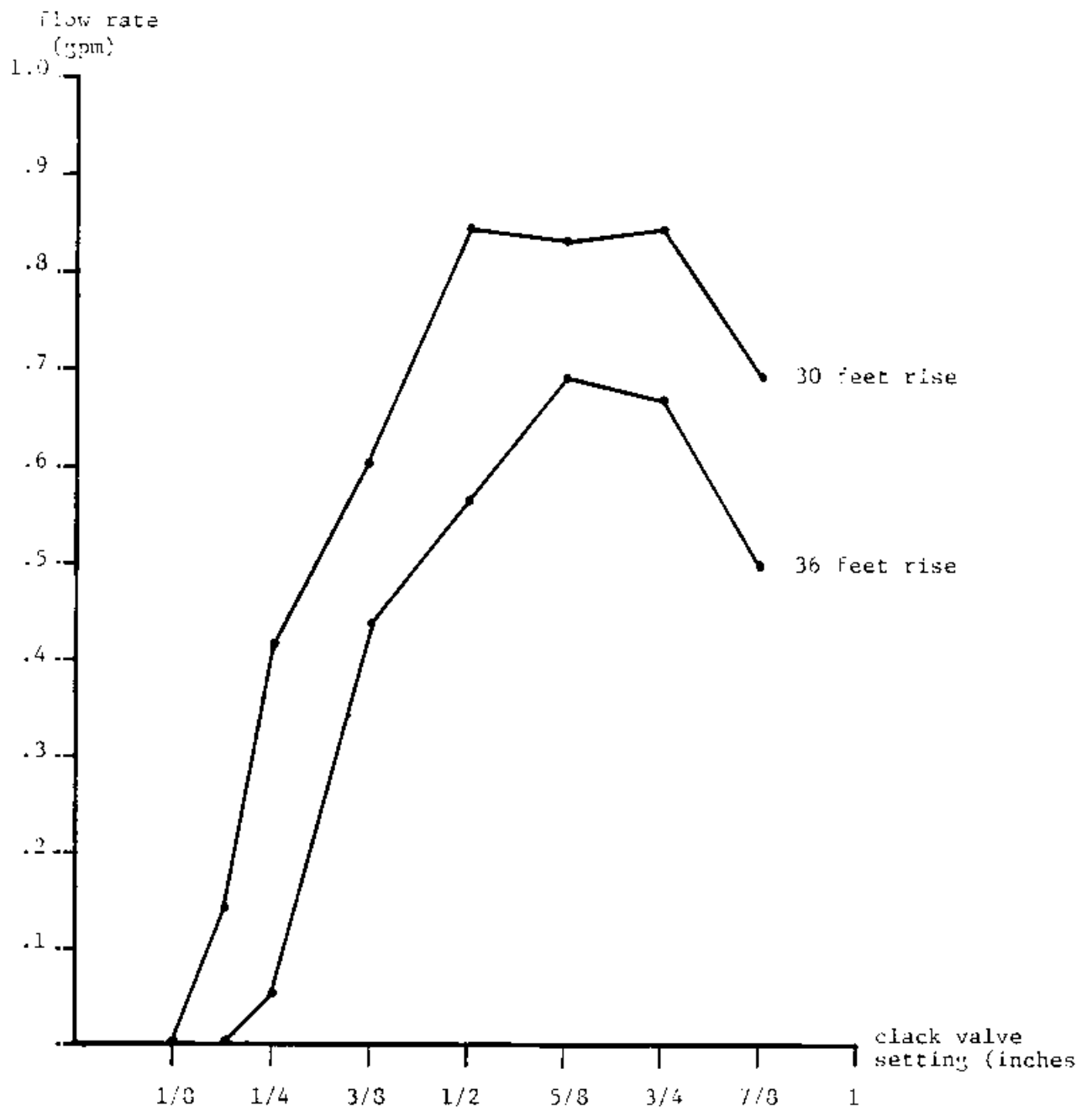| clack valve stroke (in)	clack valve stroke per minute	flow @ 30 ft rise (gpm)	flow @ 36 ft rise (gpm)
1/8	85	0	0
3/16	76	.13	0
1/4	67	.42	.06
3/8	62	.60	.43
1/2	50	.85	.57
5/8	40	.82	.69
3/4	36	.85	.67
7/8*	22	.69	.50
1	doesn't function	----	----

* clack valve almost not closing

Figure 9. Water delivered for different clack valve settings.

a hand level) or simply the inability of the pipe to transmit 15 gpm at the comparatively low fall that was utilized.

CONCLUSIONS

This project involved two major phases: masonry consisting of constructing the dam and pump pedestal and plumbing consisting of placing the ram pump and running the drive and delivery pipes. No major problems were encountered in either phase of the project. Anyone with minimal experience (or a bit of ingenuity) with diverting small streams should be able to accomplish the masonry portion of the project. The installation of the ram pump and laying of pipe is extremely simple, especially if PVC pipe is used. A builder should be cautious, however, to be certain to adhere to the manufacturer's guidelines concerning ratio of drive pipe length to fall and ratio of rise to fall (see Appendix).

RECOMMENDATIONS

A recurring recommendation of many Water and Energy Research Institute reports dealing with remote island areas is the development of dual water sources. These center around the use of properly maintained rainwater catchment/storage systems as the primary source, to be rationed in drought periods such that water from this source is always available for consumptive purposes. As a back-up, wells, rivers, or springs should be developed. Since these latter sources generally produce water of lower quality than rainwater catchment/storage systems, their primary use should be for toilet flushing, clothes washing, and other non-consumptive uses.

The demonstration that a ram pump is a simple workable device suitable for operation in Micronesia makes it feasible to bring water from a remote river, stream or spring to the immediate area of many households. For homes where it is impossible to dig a well, this could provide a convenient back-up water source to rainwater catchment/storage. This is especially true of homes on islands such as Pohnpei where there is an abundance of perennial streams. This approach is highly recommended.

On a broader scale, consideration should be given to the use of larger ram pumps for village water supply or to augment supplies to district center areas. Again the requirement is a perennial stream with a surplus of water compared to that which is required for use.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Bermin Weilbacher, Director, Department of Community Services, Pohnpei State, for suggesting an ideal site for this demonstration project. We express our sincerest gratitude to Mr. Finale Henry, Public Works Division, Department of Community Services, Pohnpei State, for his help and advice on almost all phases of the installation. Without his assistance, it might have been impossible to complete the project. Also, to Mr. Kidsen Edwin, we express our thanks for his many helpful suggestions, for his seeming love for and remarkable

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ability to perform hard physical work, and, finally for his very fine sense of humor. His presence certainly made the project much easier and a lot more fun. Finally, we thank the other staff members from the Public Works Division who at one time or another assisted on the project.

APPENDIX

Hercules Ram Pump
D & P Manufacturing
P. O. Box 97
Forest City, N.C.   28043

Installation Instructions

The installation of the Hercules is actually more important than the settings of the Hercules Clack Valve. The installation must be strong enough to prevent wash-away and the distances must be correct for proper operation. D & P has operated the Hercules successfully under very bad conditions; however, the efficiency was low. Under the proper conditions the Hercules will out perform other water powered pumps due to the Direct Flow Design used in the Hercules.

Begin with your creek or spring. Measure the amount of the water available. Catch the water in a bucket and time how long it takes to fill it. Divide the number of gallons by the time and you will get the gallons per minute. If you have a five gallon bucket and it takes one half minute to fill the bucket, the results will be 10 gallons per minute. It is preferable to have at least five gallons per minute and not less than 1½ gallons per minute. The more the better.

Next determine the amount of fall (incline) from your spring or creek to the position you plan to install the Hercules. You must have a fall of three feet, but five feet or more is preferred. To measure the fall, run a string from the spring or creek down to the Hercules site. Secure the string at the water level of the spring or creek. Raise the string above the Hercules until the string is level. Use a string level or carpenters level to be sure the string is level. Measure the distance from the Hercules to the string. This is the fall. The more the better.

Now figure the rise from the Hercules to your house or garden in the same manner. IMPORTANT: See Maximum RISE (Table C).

If the distance is too far to stretch a string without a lot of sag, it is best to measure the fall or rise in short steps. Measure from the creek or spring down hill to a convenient location. Figure the fall to this point. Then measure the fall to a second point and so on until you get to the Hercules site. Add up all of the short falls to get the total fall.

You can now figure approximately how much water the Hercules can pump. F=Fall. V=Gallons/Min. R=Rise.

Formula:

$$\frac{F \times V}{R} \times 864 = \text{Approximate gallons per day.}$$

Example: A ten foot fall; 25 foot rise and 15 gallons per minute would equal 5184 gallons per day. A lot of Water!

The installation is made up of seven parts. A dam across a creek or a spring house is needed to feed the supply pipe. A screen should be placed over the upper end of the supply pipe in order to keep trash or leaves out of the system. The supply pipe can be made of 4 inch plastic pipe, drain tile, wood or even a level ditch. The length of the supply pipe is not important. Note: if the supply pipe runs up and down hills it may be necessary to make small pin holes in the pipe to release trapped air at the high points. The air can stop the flow of the water.

The feed tank can be made of concrete, a large pipe, or a 55 gallon drum works very well. The top of the tank should be equal to the water level of the spring or creek. The top should be open or well vented.

The drive pipe should be connected to the feed tank at least 2 feet below the water level. The length of the Drive pipe IS important. Its length must not be under 5 times the fall or over 10 times the fall. In other words, a ten foot fall needs a drive pipe of at least 50 feet but not over 100 feet. 50 feet would be best because of the expense of the drive pipe. The Supply pipe length must be varied in order to get a correct Drive pipe length. Make no mistake; the drive pipe length is important. SEE: TABLE A. The drive pipe should be made of 1 inch or 1½ inch galvanized steel pipe. SEE: TABLE B.

Plastic pipe should not be used for the drive pipe unless it is set in concrete. The plastic will shake and cut efficiently down and may even burst under pressure if not securely held in place.

Shop around and try to find some used steel pipe at a good price if cost is a problem.

The Hercules should be set level on a solid foundation. The drive pipe should be straight and feed into the Hercules with only a slight bend in the pipe. A gate valve can be used to shut the water off but use only a gate type valve. The drive pipe should have no obstructions so the water can move freely.

The delivery pipe can be steel or plastic. SEE TABLE B for size. A valve of any type should be used to prevent the water from draining back down from the storage tank should you ever need to replace a Hercules part. A delivery pipe valve is also useful in that it can be closed slightly to provide back pressure on the Hercules until the delivery pipe is full. Then the valve can be opened fully.

Your entire Hercules system should be protected from freezing. Pipes enclosed in insulation or under the earth. The Hercules itself should be enclosed in a small block house or a pit with drain. Some people who use the Hercules for irrigation in the summer, drain the system in the winter and do not insulate. Just be sure all the water is out of the system. Of course, for our southern friends this is unnecessary.

This booklet contains more details than necessary; however, if you follow these suggestions closely you will have an installation you can be proud of and which will serve you well.

OPERATING INSTRUCTIONS

The start up of a Hercules is easy. Feed the supply water into the drive pipe. If you are using a gate valve between the drive pipe and the Hercules open it fully. Water will flow out the clack valve. The drive pipe must be full of water with no air. Hold the clack valve down to the force out all air. Adjust the collar on top of the clack valve to a proper stroke of about ½ inch. However, the setting should not be so great that it drains the source. At first the Hercules will pump and stop. Pull the clack valve up and down to restart it. If you are using a valve between the Hercules and the delivery pipe, close it almost closed. If you are not using a delivery valve then it will be necessary to pour some water in the delivery pipe to provide enough back pressure to continue the cycle. As the Hercules pumps more and more the strokes will become like clock work and continue on and on.

A snifter hole is located in the brass check valve. You will note that water spurts out of the snifter hole on each stroke. This is necessary because a small amount of air is taken into the Hercules on each stroke and this keeps the air chamber full of air as it should be.

You can now adjust the collar on the clack valve up or down to suit you needs. Remember, do not open the clack valve too far. You might drain the source. Additional weight may be added to lengthen the time of the stroke. Steel washers work fine. This is unnecessary unless you are using a fall of over 15 feet. Remember: The slower the stroke, the more you pump. This sounds backwards, but it's true! The more water you waste the more you pump.

TABLE A
Drive Pipe Length

FALL OF	DRIVE PIPE LENGTH	
	Minimum	Maximum
3 ft	15 ft	30 ft
4 ft	20 ft	40 ft
5 ft	25 ft	50 ft
6 ft	30 ft	60 ft
7 ft	35 ft	70 ft
8 ft	40 ft	80 ft
9 ft	45 ft	90 ft
10 ft	50 ft	100 ft

TABLE B
Size of Drive Pipe and Delivery Pipe

FALL	FLOW IN GPM	DRIVE PIPE SIZE	DELIVERY PIPE SIZE
3 ft	$1\frac{1}{2}$ gpm	1 inch	1 inch
3 ft	5 gpm	1 inch	1 inch
4 ft	5 gpm	$1\frac{1}{2}$ inch	1 inch
5 ft	5 gpm	$1\frac{1}{2}$ inch	$1\frac{1}{2}$ inch
over 5 ft	over 5 gpm	$1\frac{1}{2}$ inch	$1\frac{1}{2}$ inch

TABLE C
Maximum Use

WITH A FALL OF	MAXIMUM RISE
3 ft	20 ft
4 ft	35 ft
5 ft	50 ft
6 ft	60 ft
7 ft	70 ft
8 ft	80 ft
9 ft	90 ft
10 ft	100 ft
ETC	ETC