Ram Pump Reprise

Reviving Gold Rush Technology in Alaska

If I hadn't recently been to a workshop on hydraulic rams at the Midwest Renewable Energy Fair, the pear-shaped cast iron bell rusting away behind the main lodge at Chena Hot Springs Resort might have escaped my notice altogether. It was tucked away anonymously amidst a small cache of relics from Alaska's gold rush heritage, overshadowed by far larger sluices and dredge buckets, whose hydraulic past was much easier to discern.

Gwen Holdmann

Being somewhat equally fascinated by history and hydropower, I was curious to learn if the pump had actually been used at Chena Hot Springs Resort, where I work as vice president of new development. I started by asking the current resort owner, Bernie Karl, about the origins of the ram. To his knowledge, its existence on the property stretched back as long as his tenure did, but he didn't know anything about how it had been used or why it had ended up sitting behind the lodge. Browsing through the many historical pictures from the resort didn't help either; I could see no apparent sign of a water ram or penstock in any image.

The supply tank situated in the creek, with the geothermal well house and storage tank in the background.

Historical Sleuthing

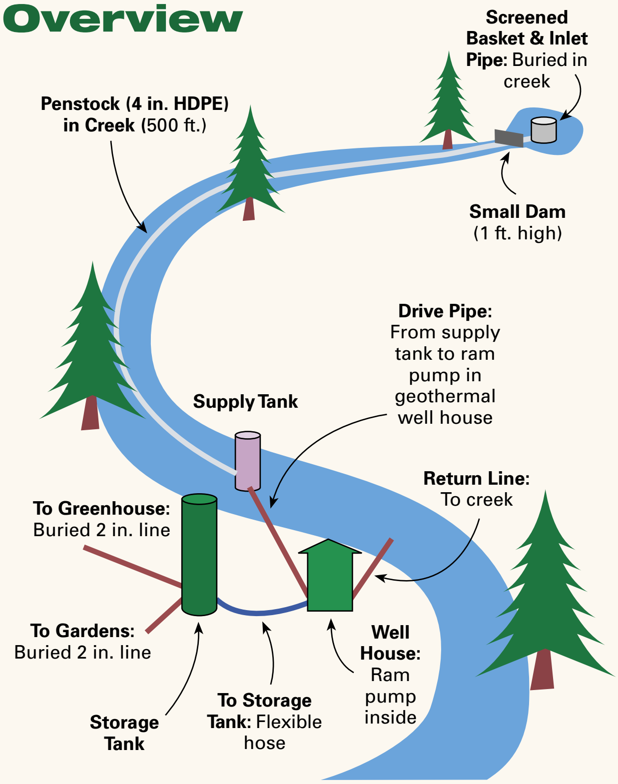
I took a closer look at the ram pump itself. It was in rough shape, and the impetus (or waste) valve was broken off. I peered inside the manifold, and saw the telltale white, calcium carbonate scaling that anyone who has worked around a hot spring for long is familiar with. Calcium carbonate precipitates out of the hot water as it cools, such as it does while flowing any distance through a pipe. Since no other hot springs are in the near vicinity, this gave me the clue I needed to be fairly certain that the pump had been used on site. In addition, I suddenly had a pretty good idea of what its original purpose may have been.

Chena Hot Springs is an oasis tucked into Monument Valley, amidst granite spires rising out of the rolling, hilly landscape of interior Alaska. Today it is accessed via Chena

System Overview

The water enters an artificially formed settling pool just behind a small dam (about 1 foot; 0.3 m high) and enters the screened inlet basket. The supply pipe comes out of this basket well below the water surface, and is buried in the creek bed for a distance of 20 feet (6 m). The 4-inch diameter supply pipe continues 500 feet (150 m) to the supply tank, and then enters a 2-inch steel pipe that goes directly to the water ram.

The ram is 40 feet (12 m) from the supply tank, on the bank of the creek. The water enters the ram, excess water is returned to the creek, and the remaining 15 percent is pumped through a plate heat exchanger (the heat exchanger has artesian geothermal fluid feeding it from the well at 12 gpm). This increases the water temperature by 50°F (28°C), and then the water is pumped up 25 feet (7.6 m) to a storage tank.



Ram Pump Basics

With a background in mechanical engineering, I have a real fascination for ram pumps. With no other visible energy inputs, they can appear to be perpetual motion machines until you understand what is going on below the surface. Their simplicity of design is genius, and they are real mechanical works of art. These pumps deliver water continually with no electricity or other added energy, and very minimal maintenance.

A ram pump uses the downhill flow of water to pump a portion of it uphill. You can pump up to 25 percent of your supply water, depending on the drop and the lift. Ram pumps will work on sites with 3 to 50 feet (0.9–15 m) of head (vertical drop) and can deliver to elevated sites far from the pump and source.

Ram pumps are quite efficient for a mechanical pump—more than 75 percent in many cases. Efficiency is calculated by multiplying the amount of water delivered by the delivery height, and then dividing by the amount of water consumed times the input head. And with enough head and flow, ram pumps can deliver thousands of gallons per day up to 500 feet above the pump site. The output of a ram pump system can be estimated by this formula:

Water Delivered = Available Water x Source Fall x 0.5 ÷ Delivery Height

The price range for a new pump is US$250 to $1,700, depending on size, materials used, and durability. When including steel drive pipe, metal ball valves, and other quality components, the price can appear high. But you will end up with a system that will last for decades. Some of the less expensive pumps are plastic, and designed to work at low head and flow. They are not able to take the incessant beating of the "hammer effect" that many ram pump installations will dole out to the pump and drive pipe fittings.

Five different ram pump sizes are available from Rife Hydraulic Engine Manufacturing Company. Other excellent pumps are on the market, including Folk brand ram pumps, which have a slightly different design, and use durable, space-age materials in the valves. (See *HP40* for a Folk ram pump installation article.)

A ram pump usually involves more work to set up than a motorized pump, but is extremely reliable and tough. I'm pretty sure they will outlast any electric pump you would choose to compare them to, and a solar-direct-powered pump could never match their 24-hour-a-day availability.

Ram pumps, old and new.

Hot Springs Road, a well-maintained, year-round road that ends at the resort, 60 miles (97 km) northeast of Fairbanks, Alaska. However, when Chena Hot Springs was discovered by prospectors from Fairbanks in 1905, it took them well over a week to reach what was then a very remote location. What they found, by following steam rising over the hillside, was a geothermal anomaly consisting of sixteen hot springs confined to a narrow stretch along the bed of tiny Spring Creek.

Once word of the discovery of hot springs in the Fairbanks vicinity spread, a clientele developed quickly and facilities were constructed. The original discoverers built a series of pools directly into the creek bed to contain the upwelling hot water, but they still had to contend with the cold water continually flowing down from Spring Creek at a much higher flow rate than the hot springs were producing. Eventually, they must have looked for a way to separate the hot water from the cold water, and maybe even pump it indoors into the first primitive lodge built there. This is likely where the ram pump came into play.

Spring Creek has a very consistent drop along its length, with approximately 1 foot (0.3 m) of drop for every 50 feet (15 m) of distance. It would have been a relatively simple matter to use this head to operate a water ram for pumping the hot water directly from the springs to use for bathing. And there are certainly descriptions detailing the pleasures of such hot water being pumped into the lodge for use by guests. Later proprietors of the resort came up with a far less elegant solution to accessing the hot springs—they simply used heavy equipment to reroute the creek and expose the hot springs in a series of constructed holding ponds, which is how it still is today.

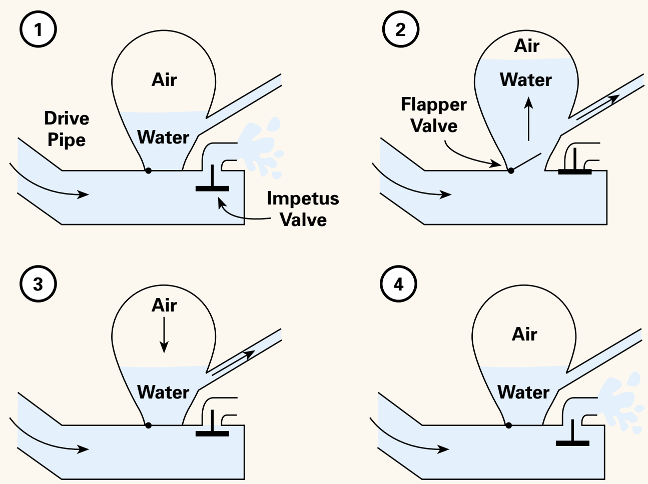
How a Ram Pump Works

All ram pumps work on the principle of momentum, which is controlled by a cycle set up by the interaction of two valves—an impetus valve and a flapper valve—in the pump.

1. When the impetus (aka "waste") valve is opened (this must initially be done by hand to start the pump cycling), water begins to flow down the drive pipe and through the impetus valve as in Figure 1.
2. The drive water velocity increases until water friction slams the impetus valve shut, as in Figure 2. The momentum of the water forces open the flapper valve and pushes water past it to pressurize the air chamber above the water level.
3. In Figure 3, the water pressure above the flapper valve overcomes the spent momentum below it, forcing the flapper closed again. The water that made it past the flapper in Figure 2 is then forced by the extra air pressure out the delivery pipe and up to the delivery point.
4. Since the momentum of the water coming down the drive pipe was spent, the pressure in the impetus area momentarily decreases to zero, the impetus valve falls open, allowing water to flow down the drive pipe again as in Figure 4 (just like Figure 1), starting the cycle over again.

This process occurs over and over until something happens to stop the cycle. Ram pumps can cycle anywhere from 25 to 300 times per minute. The frequency of the cycle is adjustable by changing the length of the stroke of the impetus valve. A longer stroke produces a lower frequency. Weight added to or subtracted from an impetus valve, and even springs, have been used to adjust the frequency. Lower frequency means more of the supply flows to and through the pump and more is pumped up the delivery pipe.

The stroke is adjusted to restrict the amount of water used to the amount available from the source, or if the supply is unlimited, to regulate the amount delivered to match the amount needed.



Gwen at the dam site, with the partially buried stainless steel inlet.

New Challenges

Although accessing the hot water is no longer a problem at the resort, a new challenge arose during the summer of 2004. The owners of Chena Hot Springs Resort mandated that we convert to 100 percent renewable energy (RE) to power the resort by the end of 2005, and in the process become a working showcase for RE and sustainable development for Alaskans. I was put in charge of this ambitious project. My three primary responsibilities were to:

- Create a renewable energy center
- Start an organic garden and a production greenhouse (geothermally heated, of course)
- Organize the construction of a 400 KW geothermal power plant to provide a primary energy source for the resort

Finding the water ram gave me an idea that could combine all three of these projects. Geothermal water is great for bathing humans, but not so great for watering plants. While our geothermal water actually meets drinking

Gwen Holdmann shows off Chena Hot Springs Resort's Renewable Energy Center.

water standards for total dissolved solids (TDS), it contains slightly elevated levels of salt. We probably wouldn't notice the effects over one season, but over several years, the cumulative effect of salt leaching into our soil would cause some real problems for our fledgling gardens.

The gardens are located beyond the reach of the existing cold water plumbing system. Throughout the early part of the 2004 season, we kept our plants happy by providing water through a lengthy hose system and by hauling water in 55-gallon (210 l) barrels to the greenhouse. The ideal solution was clearly to get the water from Spring Creek, which is adjacent to all the garden areas. But this had two disadvantages. The water close to the hot springs was mixed with the high sodium content geothermal water, and the water we could collect further upstream from the springs was a frigid 38°F (3°C).

Installation

To overcome both problems at once, we installed a small dam and built an inlet using a recycled 4-foot (1.2 m) diameter stainless steel basket, which we buried 3 feet (0.9 m) into the creek bed to use as the intake screen for the system. This inlet system was installed approximately 500 feet (150 m) upstream from the main hot springs area, and well above the zone where the hot water is discharged into the creek. For a penstock, we installed 4-inch-diameter HDPE pipe, which is heat-welded together.

We pulled the pipe sections directly down the creek bed by using a walk-behind trencher, so we would disturb the vegetation along the creek banks as little as possible. Once we had installed enough sections to provide plenty of head (vertical drop) to operate the ram, we connected the penstock to the base of a water tank installed directly into the creek bed. It's not generally recommended to install pipelines in creeks because of floodwater debris. But this creek is not fed by runoff. It is 90 percent spring fed, and has extremely consistent flow year-round—definitely not prone to flooding.

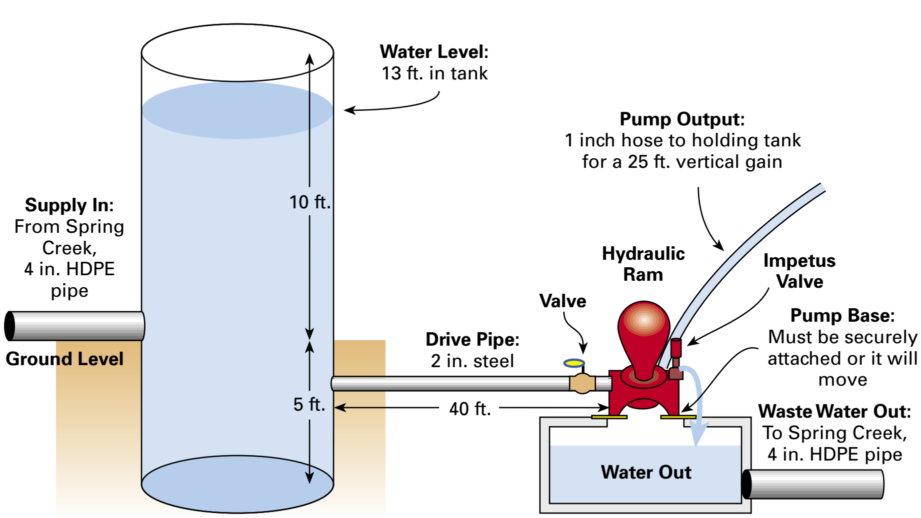
We assembled the supply tank ourselves out of a recycled 56-inch diameter, 15-foot-long (4.6 m) pipe, which we welded a steel base onto. This tank was buried approximately 5 feet (1.5 m) into the creek bed, and was designed to act essentially like a giant elbow in the system to reduce friction loss.

The penstock delivers far more water to the tank than the water ram (which operates off about 15 gpm of flow) could ever use. However, we wanted to leave our options open to use the extra water delivered for other projects. For example, we are also installing a LH1000 hydroelectric turbine, built by Energy Systems & Design, and supplied by ABS Alaskan. The water tank allows us to access this pressure head and flow from several different locations on the tank with minimal friction loss.

Our gardener, Keegan Kuhn, provided us with the number of gallons per day of fresh water we needed for our gardens (700 gallons; 2,650 l), and we then consulted with ABS Alaskan and the Rife Hydraulic Engine Manufacturing Company to size our ram. We wanted to use a Rife ram not only because of their excellent reputation, but also because the antique ram I had found is a brand now built by Rife.

In the end, we decided to use their largest ram (#5) to pump 1,600 gallons (6,000 l) per day from 9 feet (2.7 m) of available pressure head in our storage tank to a holding tank 25 feet (7.6 m) higher. We actually used a second 56-inch-diameter pipe standing on the creek bank as our storage tank, since our supply tank had worked so well.

Chena Hot Springs Resort Ram Pump



We had a little scare when we first filled our supply tank. The supply tank was supposed to provide the water pressure to operate the ram pump. The level of the water in the supply tank should be the same as the level of water at the inlet, or just slightly lower due to friction loss in the pipeline. But since the tank is 500 feet (150 m) downstream, and therefore downhill from the inlet, the water level in the tank should be higher than the level of the creek by the same vertical elevation difference as between the inlet and the tank.

This water "head" provides the feed to operate the ram, so having enough water head in the tank is pretty important. I had surveyed a drop of 8 feet 7 inches (2.6 m) along this section of the creek, but when we opened the valve to fill the tank, the water barely trickled in and only 2 or 3 feet (0.6–0.9 m) of water stood in our tank after 24 hours. We surmised that there must be air trapped in our penstock, and after repeatedly flushing the tank, we eventually managed to purge the penstock of air and measured the head at 9 feet (2.7 m), which exceeded our expectations.

When we installed the ram, we intended it for year-round use—quite a challenge in the extreme winter temperatures we have at the resort. But the warm ground that never freezes around the springs helps keep the buried pipelines from freezing, and we have plans for tapping one of our artesian geothermal wells upstream to keep the inlet and penstock ice free. For this winter, we chose to shut down the pump in early October during freeze-up because there wasn't anyone on site continually to baby the system and make sure nothing froze up. We removed the pump and drained all the lines, and the system is in hibernation until spring.

Pampered Plants

Chena Hot Springs' owner Bernie Karl had a small heat exchanger he wanted to install in the system. He wanted to warm the water from Spring Creek after it exited the ram pump and before it went up to the holding tank, using the artesian flow from our hot water well.

We attached a valve to our geothermal wellhead, which flows at about 550 gallons per minute with 9 feet of standing head, and allowed the hot water (165°F; 74°C) to flow out of this valve and through the heat exchanger at a relative trickle of 12 gpm. The water ram pumped the cold water through the other side of the heat exchanger at just over 1 gpm.

The gardens at Chena Hot Springs Resort.

This arrangement allowed us to heat the cold water by nearly 50°F (28°C)—to 85°F (29°C). Once it actually reached the gardens, it had cooled to 65°F (18°C), but this still made for some happy plants, according to our gardener. We did lose some flow in installing the heat exchanger, which is why we installed a Rife ram one size bigger than we otherwise would have needed.

Renewable Resort

Although the planning and layout for the system was more time-consuming than we had anticipated, the actual installation was fairly easy. Operation has been completely trouble free to date. In fact, the water ram hasn't missed a beat since the minute we started it up.

The ram pump has become a huge attraction at the resort, and nearly everyone who visits sees it as they wander about the resort property, or as part of an organized tour. It has become the showcase for our new Chena Renewable Energy Center, which opened on August 10, 2004.

The Renewable Energy Center is a joint project between Chena Hot Springs Resort and ABS Alaskan. The center highlights all types of renewable energy and also promotes conservation. We have planned a series of RE projects for the center in addition to the ram, including the LH1000 water turbine, demonstration wind- and solar-electric systems, and a 400 KW geothermal power plant. Getting back to our roots with the water ram project has been a great first step in our renewable journey.

Access

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