FLORIDA RURAL WATER ASSOCIATION

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Can Two Elevated Tanks Work Together in the Same System?

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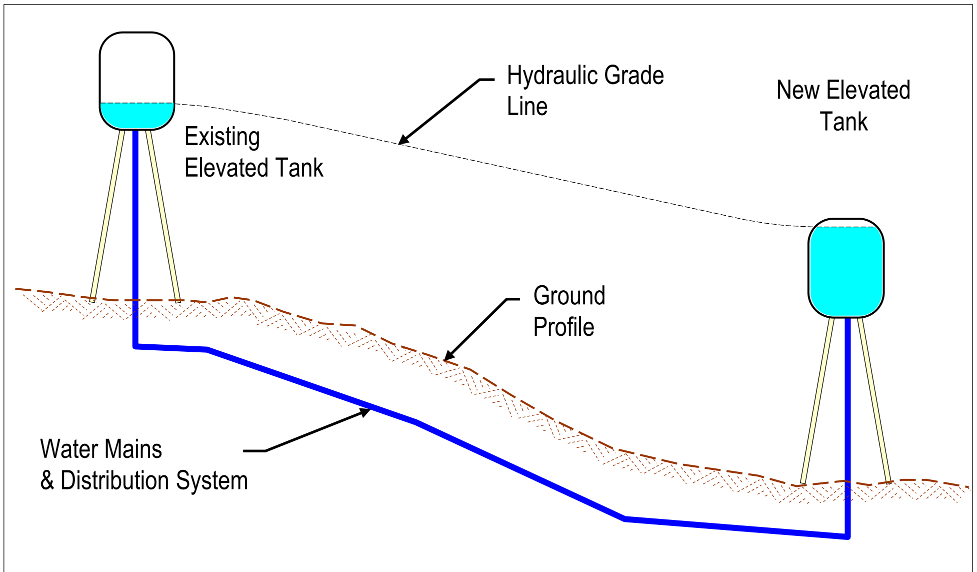
I have seen television talk shows where the question is posed to the husband, wife and audience, "Can this marriage be saved?" He says this. She says that. The moderator might try to help the couple on one show, but turn the channel and the moderator is encouraging disagreement, throwing gasoline on the fire or bringing the "best friend" on stage. Years ago these types of shows might actually be educational, but in today's race for ratings the shows quickly degenerate into arguments and flying folding chairs.

Pretend for a moment that we're together on a utility talk show with the subject of, "Can two elevated tanks live together in the same water distribution system?" The moderator, operator and engineer are earnestly discussing all the issues. Does this sound exciting? Now stifle that yawn! Well, maybe you're not glued to the show. Although it may not be titillating to the average viewer, it is for the system with this problem.

Over the past months we've had several water systems call us about similar problems they're having with new elevated water tanks. The upper tank only operates on the lower portion while the lower tank overfills and never empties. The design engineer has tried to provide answers but the water system is still deeply unsatisfied. The two tanks do not work together (see the diagram below).



Two (2) Elevated Tanks in a Distribution System

Why did this happen? Whose fault is it? Is it an operational problem or a design problem?

What must be done to correct this problem and allow both elevated storage tanks to operate in unison and float on the system (without adjustment to operational levels)?

Elevated tanks hydraulically "float" on the water system ensuring adequate water volumes to maintain system pressures at a uniform level. The tank empties during times of high demand and fills at night and other times when water demands are low. Wells pumps or high services pumps supplement the pressure and flow from the elevated tank. As the water system grows, the high service pumps provide more and more of the demand. But the elevated tank still rules or defines system hydraulics.

Water system hydraulics can be visually represented as shown in the below figure as a hydraulic grade line. The hydraulic grade line is a plot of the water pressure in a distribution system from the water plant to some remote point. During times of high demand, pressures drop in the system extremities and the hydraulic grade line drops slightly. When flows are low and system pressures stabilize, so does the hydraulic grade line – it flattens out. If this explanation sounds technical, it is.

Both elevated water tanks will have their own hydraulic grade lines and it is up to the design engineer to make sure these grade lines match and the tanks work together -- today and in the immediate future. There are several ways for the designer to ascertain that all of these components will match up. They include: a water system computer model; system-head curves for average daily, maximum daily and peak hour demands; or hydraulic grade line calculations. If the engineer overlooks this step you could end up with the two tanks fighting each other.

Operational levels are not adjustable without additional mechanical devices or extraordinary daily adjustment. Continuous operational adjustment is contrary to the elevated tank design choice. It is not possible to simply allow both elevated storage tanks to float on the system in unison without changing major system components (number of customers, pumps or pipe sizes).

Solutions? Let's explore possible solutions to this problem.

Install Pumps to Empty the Lower Tank and to Boost Water into the Upper Tank. Pumps might be installed to force the lower tank to empty and to fill the upper tank. This option is not realistic -- elevated tanks should reduce pumping and O&M costs, not increase them.

Shorten the Upper Tank or Raise the Lower Tank. In reality the new tank is several feet too short or the old tank too tall. Changing tank height is never feasible or cost effective.

Pressure Reducing Valve. The best fix for this problem is to divide the system into separate pressure zones -- upper from lower portion. This separation is accomplished by installing a pressure reducing valve on the mainline. The valve allows flow between the two zones while maintaining higher pressures in the upper system and without overflowing the lower tank. Arranging these pressure zones is not preferred and costs for installing a pressure reducing valve station is about $65,000 to $85,000.

Some tanks work together just fine. Elevated water tanks can be designed to work together, hydraulically speaking. There are plenty of systems that have fully functioning tanks and too many systems with operational problems.

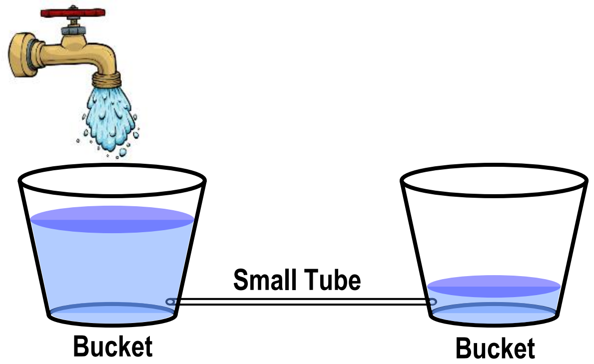
Sometimes, the best solution for a troubled marriage is separation. In this case, separation of the two tanks is the best option for this water system.

It's a costly separation for correcting hydraulic problems, but avoidable. If you are about to get a second elevated tank, please work closely with your design engineer to assure that the two tanks are compatible, hydraulically speaking that is.

Fluid Hydraulics 101. A hydraulic problem that frequently occurs with elevated tanks involves differences in frictional losses that occur when the first tank is closer to a pumping source than the second tank. In these instances, even though the overflow tank levels are set at the same elevation, the first tank will fill and run over before the second tank can be filled.

This phenomenon is caused by the need for extra energy needed to push the water through a long pipeline at the same velocity to feed the second tank. Think of it as filling a bucket of water with a small tube that is connected to a second bucket located a distance away at the same elevation but connected to the bottom of the first bucket with a small tube.

The first bucket will fill very fast and spill over before the second bucket can fill. This is because the small tube is resisting the flow of water by generating more friction.



Filling Tanks at the Same Elevations Located Far Apart. It may be possible to fill two tanks at the same elevation located far apart without spilling water from the first tank by lowering the pumping rate during the fill cycle. Although this seems counterintuitive, the reason that the method may work is that the energy to overcome friction increases by the square of the velocity. Thus a very small change in the pumping rate makes a big change in the frictional energy that needs to be supplied to equalize the tank levels when both tanks are filling.

Lowering the pumping rate can be accomplished by trial and error and does not result in any additional capital improvements. The objective is of course, to ensure that the tanks are being filled to the optimal cumulative capacity without spilling any water. Demand closer to the first tank is typically easier to supply and thus cumulative tank capacity will indicate the best tank levels that can be achieved using this method.

About the Author:

Sterling L. Carroll, P.E. is the state engineer for Florida Rural Water Association, which serves a population of 5.4 million people. Mr. Carroll assists small and medium sized water systems with engineering, permitting, and plant troubleshooting.

Mr. Carroll has over 25 years experience in the water and wastewater treatment field and has been involved in the design, permitting and construction management more than 30 water and wastewater treatment plants and over 400 miles of pipelines throughout Florida and other states for governmental, industrial and private clients.