Air Lines – Sound Investment At A Minuscule Cost

PORTAGEVILLE, MO.

For an investment of just a few dollars, you could possibly save yourself thousands of dollars over the next several years. The investment in question fits inside your irrigation well casing and is called an air line. An air line is just a piece of tubing (cheap 1⁄4-inch plastic tubing works fine) inside your well casing that can be used to measure water level.

Starting a few feet above the pump, the air line is strapped to your column pipe as it is being lowered into the water well. The other end protrudes at the wellhead and has a tire tube air valve (a.k.a., Schraeder valve) and a pressure gage attached to it via a 3-way fitting. This system accurately measures water table depth using a physical relationship: it takes 1 pound per square (PSI) of pressure to displace 2.31 feet of water. The concept works this way. The air line tubing will fill to the same level as the water in the well casing. When air pressure is introduced from the surface end of the tubing with a bicycle pump or a tank with compressed air, the water is displaced. A look at the pressure gage shows how much pressure was required for this displacement, and thus how many feet of water were displaced by multiplying the PSI reading by 2.31. Subtract this value from the length of the tubing and you have the water level. For example, if the length of the tubing was 50 feet and after pumping air into the tubing the pressure reads 10 PSI, then 23 feet of water was displaced (10 PSI x 2.31 ft/PSI) and the water table is 27 feet (50 ft 23 ft). Any excess pressure introduced into the tubing while pumping, in this case anything beyond 10 PSI, merely exits the bottom of the tubing as air bubbles.

The water level of the aquifer before the pump is turned on is referred to as the static water level (SWL). As a pump is turned on, the water level in and around the well casing drops. It may take several hours or days before the water table depth finally stabilizes. This new depth of water in the well casing is called the pumping water level (PWL). The difference in PWL and SWL is called the drawdown. Figure 1 shows an aquifer and the components of an air line.

The PWL is crucial information when selecting the correct irrigation pump. Note that the PWL is not the depth that the pump is set, but instead represents the lift required to bring water in the well to the surface.

Extremely Important for Our Region. Few areas in the country have as pressing a need for good PWL information as does the Mississippi River Delta region; this is for two main reasons which are discussed below. Even the best experts knowledgeable on local aquifers and pumps aren't able to accurately predict what the PWL is in your well. We know that the PWL is below the normal SWL (which is generally 10 to 15 feet and can be seen in uncovered wells), plus we know it has to be above the depth the pumps are set at, often 50 feet. If we are using a centrifugal pump to suck the water from the aquifer, we can further fine-tune our estimate of PWL as lying anywhere between the SWL and the physical limits of the pump to suck water. But by and large, we remain unaware of the exact depth of the PWL, yet this piece of information is pivotal in having efficient pumps. The PWL will vary from well to well, even those a few hundred feet apart, depending on how much water is being pumped, how the well was developed, if the well screens are clogging, etc. Also, even for the same well PWL will naturally fluctuate seasonally based on the overall rise and ebb of the underground aquifer.

1. Small Changes in PWL Can Have Adverse Effects. The first reason the knowledge of PWL becomes critical is that there are many high volume-low head pumps used in the region. Commonly, they are used in rice fields and flood irrigated fields employing Polypipe. Such a pump might produce 2,000 GPM and with a head of 40 feet. Head, more appropriately called total dynamic head (TDH), includes the lift (i.e., the PWL), friction loss in the column pipe, and operating pressure at the discharge end. Since we are basically referring to open discharge, where the operating pressure is zero, then TDH is just a factor of the first two items. For these types of pumping units, even small fluctuations in the PWL can turn efficiencies south and pumping costs north.

Let's assume that the design PWL is 35 feet and the column pipe friction loss is calculated to be 5 feet, giving a total of 40 feet of TDH. The pump we chose produces 2,000 GPM under these conditions. However, should the overall water table drop just 5 feet more (now it is at 40 feet), TDH has basically increased 12 1⁄2 percent. Flow rate and head on a pump behave like a teeter-totter, so with TDH going up 12 1⁄2 percent, you can estimate that the flow rate will drop 12 1⁄2 percent, or 250 GPM. Unfortunately, that isn't the only problem: the cost of water goes up! This negative phenomenon is worse for pumps powered by electric motors, since engine RPM on diesel and propane power units can be changed to make compensations. Also, note that changes in PWL has only a small impact on pivot systems, since the pumps used in pressurized systems have a relatively high TDH aspect to start off with, and a few feet of additional lift is inconsequential.

Using an actual pump curve from a typical pump used in flood irrigation (FairbanksMorse 12U.1 9PC-119412 – 1770 rpm) the expected changes in water pumped and costs can be modeled for the conditions where a water table level, initially at 35 feet, drops to 40 feet. Figure 2 shows that under this scenario the decrease in flow rate is actually 300 GPM. Figure 3 indicates that formerly water costs were 30 1⁄2 cents per acre-inch, and after the 5-foot drop they are 35 cents per acre-inch, a 15 percent increase. Part of the cost increase is that there is more head requirement, but part stems from the fact that operating point on the pump curve is no longer at peak efficiency, having moved to an operating point that is 3 percent less efficient.

The air line assists irrigators by providing them the knowledge of where on the pump curve the pump is operating at and the associated efficiency at that point. Knowing this they can decide if it is warranted to make current improvements on their pump, or at least, when the time does come to replace the pump one that closely matches the hydraulic requirements will be chosen.

To fully determine current pump performance, a measurement of flow rate needs to be made either with an in-place or borrowed flow meter. However, even without a flow meter reading, the lowly air line can give you an estimation of both flow rate and pump efficiency, if you have the pump curve. Figure 4 is a pump curve for the pump previously mentioned that was obtained from the Fairbanks-Morse website. The Best Efficiency Point (BEP) is indicated on the curve (use the 9-inch impeller) at 2,000 GPM and 40 ft of TDH. Your air line tells you that your PWL is 42 feet and from a friction loss chart you estimate that friction loss for you length of column pipe and approximately 2,000 GPM is 3 feet, thus you have a total TDH of 45 feet (42 ft + 3 ft). Going horizontally across the pump curve at 45 ft you hit the curve at 71 percent efficiency (10 percent lower then the BEP), and going down vertically you see that the flow rate is about 1,500 GPM.

The cost of fuel is so high today that a typical pump's fuel bill in one year is higher then the original cost of the pump! Table 1 shows that for a 40-HP pump it ranges from only 258 hours of operation for propane to 601 hours of operation for electricity to equal the original cost of the pump. One needs, of course, to add in the cost of pulling a unit, but it becomes obvious that sitting on an inefficient pump is like burying your head in sand.

2. Well Screens become Clogged over Time. The second reason that knowledge of PWL is important to area irrigators is that the water of many of the wells in the Mississippi River delta has large amounts of iron. A particular type of bacteria thrives on this iron in our water. As colonies of these bacteria multiply, they form slimes that can begin to clog the well screen and gravel pack. This leads to well inefficiency which means added drawdown is required to maintain the same flow amount. In an electric power unit with a constant RPM, this will show up as less flow rate. In pumping units powered by engines, idling at higher RPMs could maintain the original flow, thus masking the effect of well clogging. Changes in flow rate can be caused by a myriad of things, other then clogging well screens.

One definite way to determine if any clogging is taking place is not to focus on flow rate, but on specific capacity. Specific capacity is the well's flow rate divided by the drawdown. For example, if a well's SWL = 15 foot, its PWL = 25 foot, and it is pumping 2,000 GPM then the drawdown = 10 ft (25 ft – 15 ft) and the specific capacity = 200 GPM/foot (2,000 GPM / 10 ft). Should flow rates decrease due to the overall water table dropping, the pump becoming worn, the engine running at slower RPMs, or more head requirements being added on, the specific capacity would still remain basically the same. However, if screen clogging is leading to the flow drop, the specific capacity will decrease. Experience has shown that it is important to begin remedial efforts to clean up the encrustations causing the clogging before a 25 percent reduction level in original specific capacity occurs, or it will be too late, and the well may become impervious to future remediation treatments.

Air lines are a cheap investment and should cost no more then $25, but they could help you save some big bucks. So, anytime you have a pump worked on or a new one installed, don't forget to add the air line. And while your are at it, be sure to get a copy of the pump curve for your files. Δ

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Table 1. The hours of operation in energy costs for various horsepower and various fuel sources to equal the original investment cost of the pump.

Horse Power	ELECTRIC	DIESEL	PROPANE
25	867	810	358
40	601	582	258
60	472	448	198
100	498	448	198

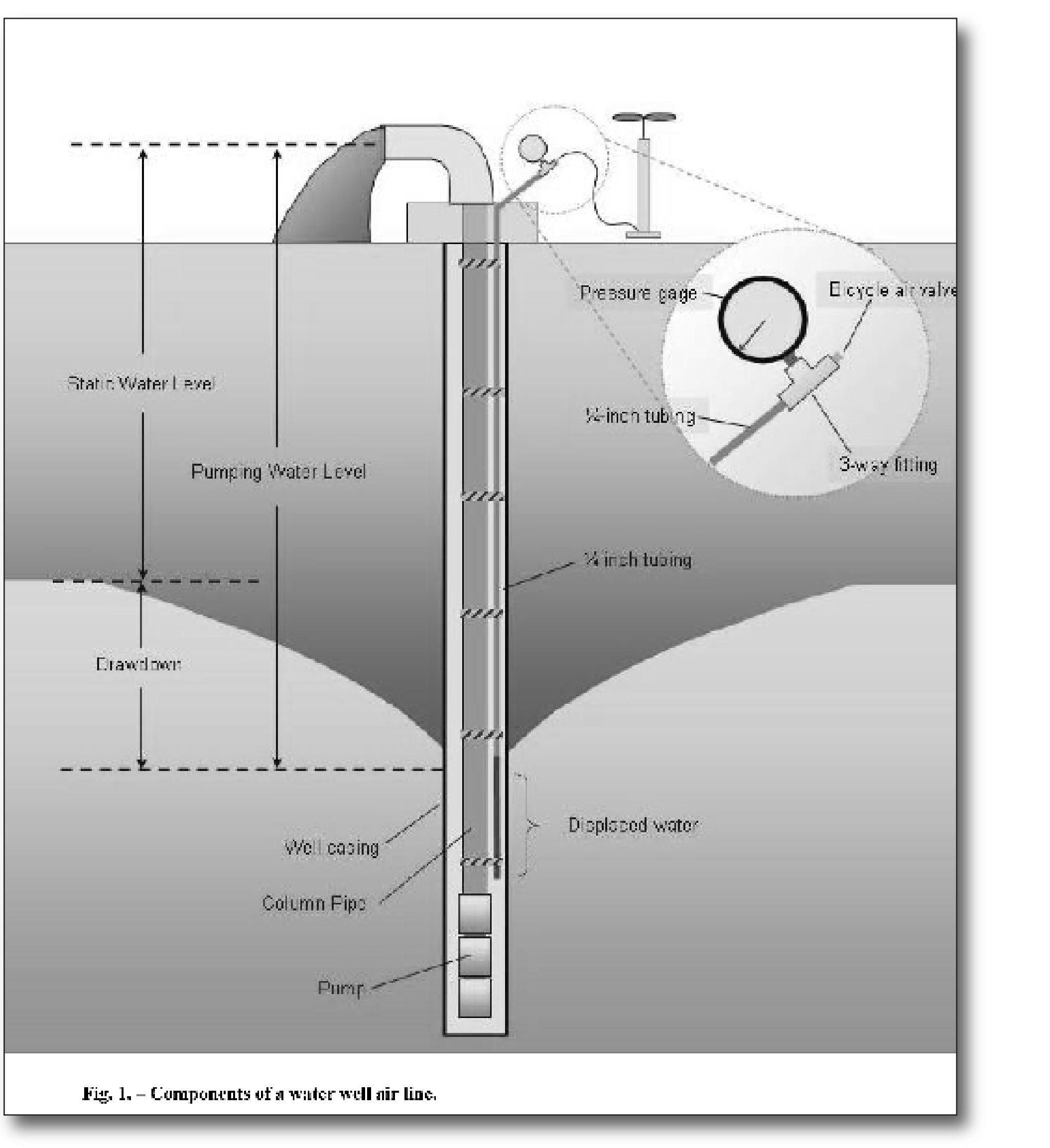

Fig. 1. – Components of a water well air line.

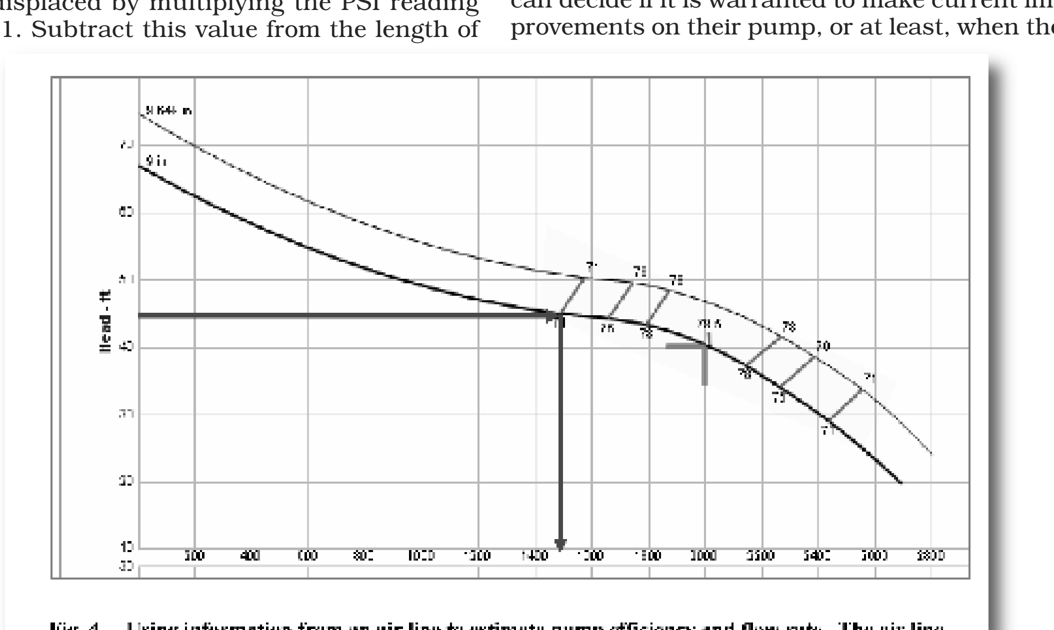

Fig. 4. – Using information from an air line to estimate pump efficiency and flow rate. The air line had indicated PWL – 42 ft and the friction loss of the column pipe was estimated from a chart to be 3 ft giving TDH = 45 ft. A line drawn across from this point hits our pump curve (bottom curve) at the 71% hash mark. Going vertically down from there indicates that the pump is producing about 1500 GPM.

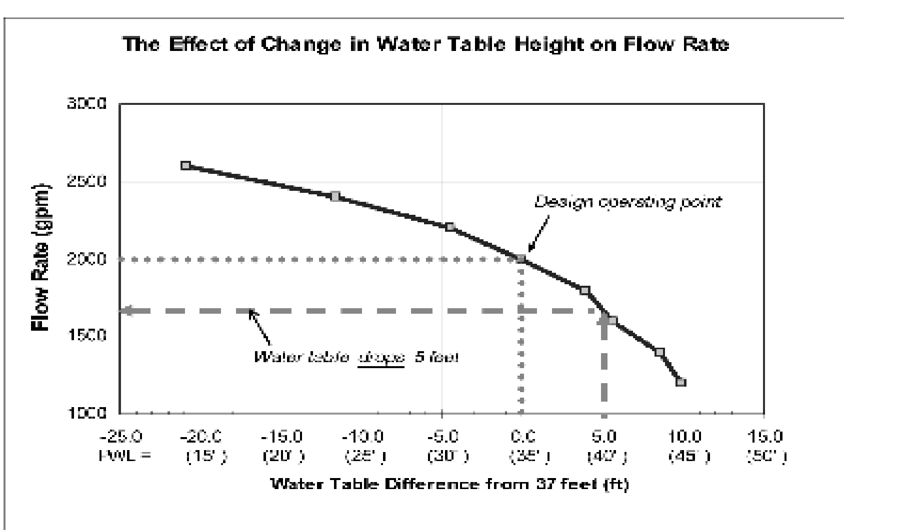

Fig. 2. – How a drop in water table depth (decreasing to 40 ft from an original depth of 35 ft) affects flow rate, in this case, decreasing flow rate by 300 GPM.

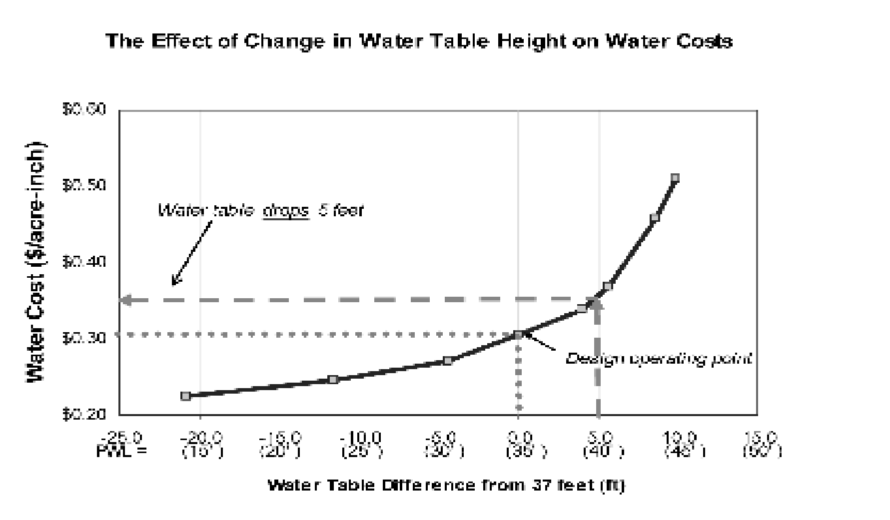

Fig. 3. – How a drop in water table depth (decreasing to 40 ft from an original depth of 35 ft) affects the cost of water, in this case, raising the cost of pumping water 15%.