4. Basic Water Supply System Design

Cattlemen are increasingly adopting rotational grazing approaches that involve smaller paddocks with more frequent movement of cattle from one paddock to the next. Supplying water to multiple paddocks can be a significant challenge in rotational grazing systems. When looking to graze cattle in crop fields, cattlemen will need to figure out how to reliably supply water without using permanent tanks. For many landowners, concerns over the cost of installing permanent tanks, compaction around the tanks, and general inconvenience of having permanent tanks in crop fields have deterred them from grazing these fields. One promising solution is to use portable stock tanks with moveable surface tubing (Figure 10).

Buried water lines and mounted tanks are great for providing water to grazing livestock, but with multiple paddocks the number of tanks and amount of pipe to be installed can be overwhelming. Portable tanks and tubing allows for expanding water infrastructure without the major expense of permanent installations. The tanks can be moved with the livestock rotation, which provides a water source near the livestock and minimizes issues of trampling (compaction and mud) that would otherwise occur in areas surrounding permanent tanks.

Portable water tanks and tubing can be moved with an ATV. Tubing is available that is specifically made to be moved regularly as a part of a towable irrigation system (e.g. K-Line Irrigation). This tubing has advantages over common polyethylene tubing in that its special fabrication allows the tube to not hold to a 'memorized' shape. Rather, the tubing conforms to the lay of the land each time it is moved. Portable water line does not provide frost protection, however, and can only be used in above-freezing temperatures. Tubing typically comes in rolls of 300 to 370 feet with tube diameters of 1 ¼ to 2 inches. Rolls of tubing are connected together with cam-lock fittings. The producer can add to the line or shorten it as needed. The fittings used in a portable water system need to be very strong and durable, they should be made specifically for use with towed equipment.

Figure 10. Portable stainless steel stock tank (K-Line Irrigation). Photo credit Jason Gross.

Water system design and tube layout follow the same design criteria used with buried PVC pipe. Operational and static pressure at the hydrant must be carefully calculated so the water flow overcomes friction and elevation losses in the tubing. Flow capacities of the water source need to be measured and matched to the number of livestock. Portable air/vacuum vents should be installed along the length of the tube (Figures 11 and 12). In rough pastures, place air vents at the ridge crests to protect the tube from air locks and vacuum problems. Depending on the water flow, pressure, and the topography, up to 3,000 feet of surface tubing is possible.

Figure 11. K-Line 1 ¼" tube connected to water hydrant with a Waterman AVP 1 air vent in the pod. Connections made using cam-lock fittings along the length of the tube. Photo credit Jason Gross.

Figure 12. Close-up of portable air/vacuum vent within protective pod. Photo credit Jason Gross.

Normally the tubing is connected to a hydrant and water is supplied under pump pressure, but water can also be supplied as a gravity system using a large tank or cistern. The water level in the cistern or source tank must be at least 10 feet higher than both the highest crest of the tube and maximum elevation of water in full stock tanks. The tube will have to be well vented and the inlet riser from the cistern tank may need a gravel filter to prevent issues with excessive algae or debris. Cisterns can be made from existing stock tanks at windmills or solar wells or using poly tanks like those used for fertilizer storage.

Portable water tanks have limited capacity compared to conventional stock tanks. To accommodate quick and easy moves with an ATV, portable tanks may only store 20-30 gallons of water. The pasture system needs to provide adequate reserve to manage a pump or well failure. Large permanent tanks should be located near the livestock somewhere in the pasture or field. For extra storage in pressure or gravity systems a portable cistern can be made from 1,000 or 1,500-gallon nurse tanks on running gear. These storage cisterns can also be moved with the cows and portable tanks.

Water and fence infrastructure is a large and necessary expense for any grazing operation. Like most agricultural systems, there are many options to choose from. If the grazing practice has frequent paddock moves then the cow or calf behavior will be more supportive of alternatives such as portable fence and portable water systems. These alternatives are available and can be installed using simple construction techniques. The flexibility of electric fence and portable water can be adapted to grazing crop fields and complements portable and barbed-wire fencing.

Water system design basics

The physics of water flowing through a pipe, especially gravity systems, is very complex. Water flowing through a pipe has to overcome friction losses, elevation loss or gain, air and vacuum problems, and other potential issues. This section provides a very basic method of designing a short, pressurized water line; however, it is best to have an experienced design professional assist in the layout and design. The design will determine the well capacity needed to supply the livestock water needs and the required tube diameter, and check elevation pressure loss or gain.

Total dynamic head (TDH) is the equivalent height (feet) that the water would have to be lifted (pumped) to account for friction and fitting losses in addition to the actual elevation change. Pressurized water in a pipe or pressure tank has the energy potential to move water like the elevated water in a town's water tower has the potential to distribute water to residences; the energy is just in a different form. The potential energy of elevated water can be converted from feet to psi in a pressurized line and vice versa. For water, 1 psi of pressure = 2.31 feet of elevation rise. A column of water that is 231 feet high will register 100 psi on a pressure gauge at its base. In a typical pressurized water system, the measured static water pressure at a water hydrant will need to be converted to feet of head. For example, 50 psi at the hydrant = 115.5 feet of head (50 psi x 2.31 ft/psi). In this example, a hydrant with a static head pressure of 50 psi could lift water in a pipe 115.5 feet high if there were no energy losses. In real situations, the actual elevation rise will be less due to the friction loss of the pipe and also minor losses.

Even though water is a lubricant there is energy loss through friction. Review Table 3 to estimate the friction loss for polyethylene tubing. Find your desired or measured flow rate (Q) in gpm using the left-most column and then move to the right to find the friction loss per 100 feet of length for differing sizes of tubing. If you would like to install 1 ¼-inch tubing with a flow rate of 8 gpm, then you would get a friction loss of 1.157 ft per 100 ft, which means that there is 1.157 feet of head loss per 100 feet of tubing. If your desired portable water tubing is to be 1,000 feet long, then the friction loss in the pipe can be determined as (1,000 ft / 100 ft) x 1.157 ft = 11.57 feet. This means that pushing 8 gpm of water through 1,000 feet of 1 ¼-inch tubing at 50 psi would reduce the height you could lift the water by 11.6 feet (115.5 ft – 11.6 ft = 103.9 ft).

It's important to consider the effect of water velocity on friction and minor losses and how the desired flow rate is achieved. As water velocity through tubing increases, friction losses increase at an even higher rate. Water flow rate depends upon the diameter of the tubing and the water velocity. At a constant flow rate, as the tube size gets larger the water velocity and resulting losses decrease. Another reason to think about water velocity is that water velocity can be dangerous when it exceeds 5 feet per second (indicated by the area of Table 3 that refers to "v > 5 fps"). There is a phenomenon called 'water hammer' that may occur when water flowing in a pipe suddenly stops and there is an instant surge in water pressure. This sudden surge can exceed the bursting pressure of the pipe or tube and cause a failure of the tubing. The faster the water velocity, the greater the risk for water hammer. Valves in the pipeline must be turned off slowly and care must be taken to keep debris from causing a sudden blockage in the pipe. To have minimal risk for water hammer, the tube size should be at least the next size larger than the minimum size listed with v < 5 fps. Larger-diameter tubing and fittings are more expensive, but there are good reasons to not undersize tubing.

Minor losses also deserve attention in the design of a water system. Minor losses account for energy loss as water flows through fittings, valves, or any interruptions to water flow. Minor loss tables for specific fittings and valves can be found on the internet, but in general, it is conservative to use 0.5 foot of loss per fitting, valve, and cam-lock connection in the tubing.

The last loss to measure accounts for elevation losses or gains. It takes energy to push water up a hill, as illustrated in Figure 13, but when the water line goes downhill it gains energy (pressure). Surveying the elevation path for tubing can be done fairly simply with topographical maps or GPS. Record the hydrant elevation, elevation of any peaks or valleys of the tubing path, and then make a cross-section graph such as shown in Figure 14.

PE PIPE, SIDR-PR
FRICTION LOSS ft/100 ft

Q (gpm)	1/2 inch	3/4 inch	1 inch	1-1/4 inch	1-1/2 inch	2 inch	2-1/2 inch	3 inch
	0.622 ID	0.824 ID	1.049 ID	1.380 ID	1.610 ID	2.067 ID	2.469 ID	3.048 ID
2.0	4.3052	1.0943	0.3377	0.0888	0.0419	0.0124	0.0052	0.0019
4.0	15.5401	3.9501	1.2189	0.3205	0.1513	0.0448	0.0189	0.0068
6.0	32.9268	8.3695	2.5825	0.6792	0.3206	0.0949	0.0399	0.0143
6.5	v>5 fps	9.7067	2.9952	0.7877	0.3718	0.1101	0.0463	0.0166
7.0	v>5 fps	11.1346	3.4358	0.9035	0.4265	0.1263	0.0531	0.0190
7.5	v>5 fps	12.6520	3.9040	1.0267	0.4846	0.1435	0.0604	0.0216
8.0	v>5 fps	14.2582	4.3996	1.1570	0.5461	0.1617	0.0681	0.0244
8.5	v>5 fps	15.9523	4.9224	1.2945	0.6110	0.1809	0.0761	0.0273
9.0	v>5 fps	17.7334	5.4720	1.4390	0.6792	0.2011	0.0846	0.0303
9.5	v>5 fps	19.6009	6.0482	1.5905	0.7507	0.2223	0.0936	0.0335
10.0	v>5 fps	v>5 fps	6.6509	1.7490	0.8256	0.2445	0.1029	0.0369
11.0	v>5 fps	v>5 fps	7.9347	2.0867	0.9849	0.2917	0.1227	0.0440
12.0	v>5 fps	v>5 fps	9.3220	2.4515	1.1571	0.3427	0.1442	0.0517
13.0	v>5 fps	v>5 fps	10.8115	2.8432	1.3420	0.3974	0.1672	0.0599
14.0	v>5 fps	v>5 fps	12.4018	3.2614	1.5394	0.4559	0.1918	0.0688
15.0	v>5 fps	v>5 fps	14.0920	3.7059	1.7492	0.5180	0.2180	0.0781
16.0	v>5 fps	v>5 fps	v>5 fps	4.1764	1.9713	0.5838	0.2457	0.0881
17.0	v>5 fps	v>5 fps	v>5 fps	4.6726	2.2055	0.6531	0.2749	0.0985
18.0	v>5 fps	v>5 fps	v>5 fps	5.1943	2.4517	0.7260	0.3055	0.1095
19.0	v>5 fps	v>5 fps	v>5 fps	5.7413	2.7099	0.8025	0.3377	0.1210
20.0	v>5 fps	v>5 fps	v>5 fps	6.3134	2.9799	0.8825	0.3714	0.1331

PE MATERIALS AND PRESSURE RATINGS

Material	SIDR	PR (psi)	72% PR (psi)
3408	15	100	72
3306 & 3406	15	80	58
3408	11.5	125	90
3306 & 3406	11.5	100	72
3408	9	160	115
3306 & 3406	9	125	90
3408	7	200	144
3306 & 3406	7	160	115
3408	5.3	250	180
3306 & 3406	5.3	200	144

Hazen-Williams C = 135
ASTM-D-2239, PE Pipe
Pressure Rating (PR) @ 73 F varies with pipe material

Table 3. Friction loss table for polyethylene tubing (Missouri Livestock Watering Systems Handbook, Chapter 5).

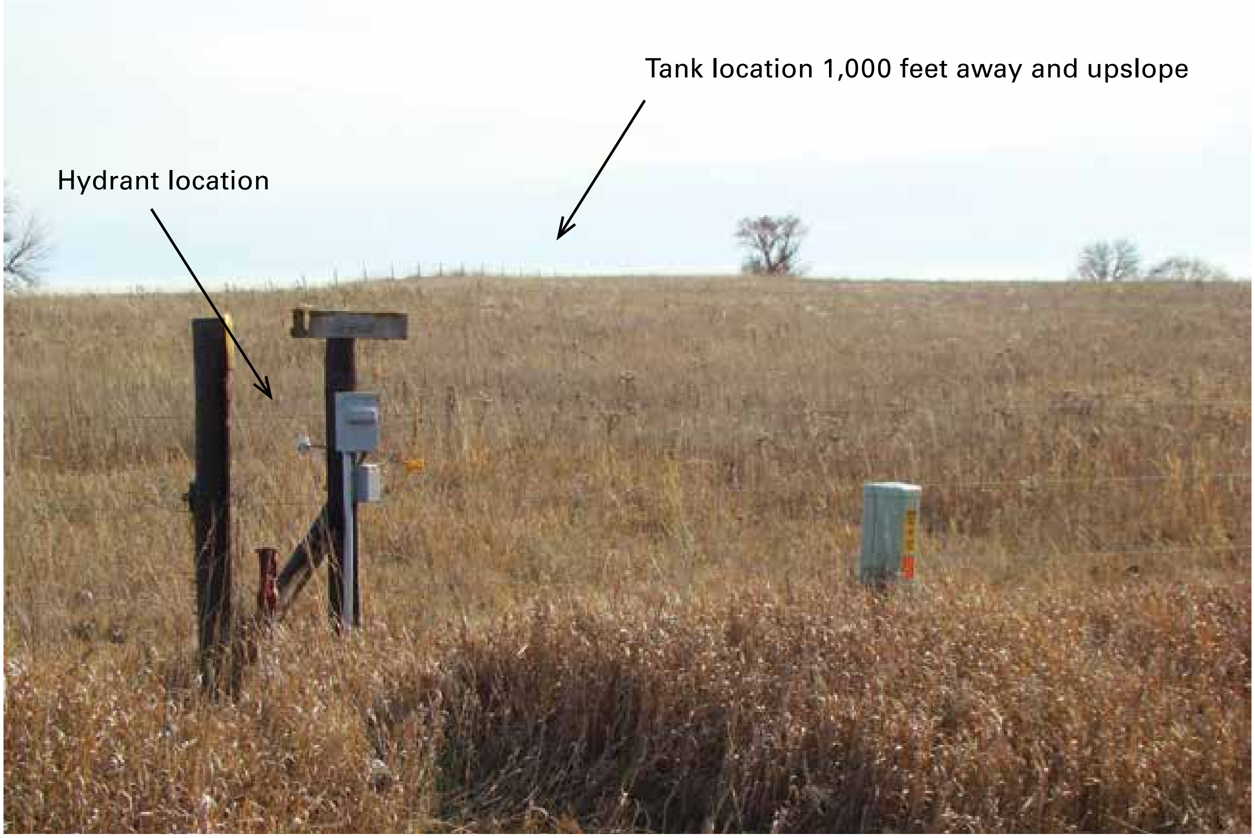


Figure 13: Tubing path showing the water tank and hydrant locations. Photo credit Jason Gross.

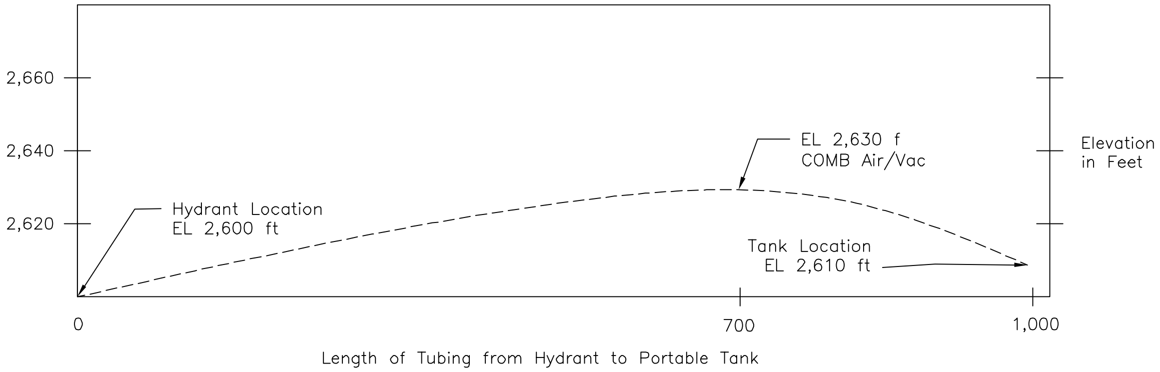


Figure 14. Cross-section view of tubing elevation path.

The next consideration is the use and position of air/vacuum vents and combination or 3-way valves (Figure 14). An air/vacuum vent is a simple attachment to a pipeline that allows air to be released as the pipe is filled with water or to allow air in while the pipe is draining or during normal operation to prevent a vacuum that could collapse the pipe or tubing. Combination valves or 3-way valves have the same function for air and vacuum release, but also can release small air pockets that can develop while water is in the pipe. All groundwater has small amounts of gases in it. As water flows over a rise, the water velocity slows down and may reach a point where gas bubbles can form and cause an air lock. This air lock can act as a blockage and not allow water to flow to the tank. Combination valves should be installed into tubing cam-lock connection points at every rise of 20 feet or more in elevation. An air/vacuum vent must also be installed at the hydrant. If this isn't done, then the tubing must be disconnected from the hydrant while closing the hydrant valve to let air into the tubing. If the valve at the tank is self-venting then an air/vent is not necessary.

Flow and hydrant pressure measurement

The capacity of the well in terms of flow rate is a major determining factor in the management of grazing cattle. Water consumption for cows or calves could reach as high as 20 gallons per day per head, but the timing of when cattle drink is also important. A paddock with large-volume permanent stock tanks does not require a high flow rate to keep up with cattle drinking the water, which accommodates longer recovery times with lower-flow water supply. A good resource for recommended well flow capacities and recovery times for permanent tanks can be reviewed in the Nebraska NRCS engineering guide "Nebraska Stockwater Pipeline Handbook" Chapter 2.

Portable tanks are a different story. The advantage of a portable tank is that it can be moved easily with an ATV. Producers don't have to wait to drain a large tank and then use a loader or a truck to move the tank. This ease of handling allows a producer to frequently (e.g. daily) move tanks to new locations. By frequently moving tanks, there will be a better spread of manure in the paddocks, less area around tanks torn up by cattle, and less mud and fewer flies that can lead to disease. The major disadvantage of a portable tank is the lack of capacity. Portable water tanks generally do not have enough capacity, in terms of water reserve and water supply flow rate, for all of the livestock to drink at one time. However, use of portable tanks in small paddocks gives easy access for cattle to drink multiple times a day instead of filling the rumen once or twice a day.

For stock tanks that lack multi-day capacity, University of Virginia Extension suggests that the well and delivery system should provide at least 2 gpm of water flow per head of tank capacity (# animals that can drink at one time from the tank). For example, a portable tank with one-time drinking capacity of 2-4 head, needs at least 8 gpm of continuous water flow delivered to the tank. Since there may be multiple water tanks supplied by a common well, the well must be able to supply water to the tanks simultaneously, although each tank may not be fully occupied and require peak capacity. For illustration, for one well to provide water to each of three [2-4 head] portable tanks in a grazing system, the well may have to provide 12-18 gpm (2 gpm/hd x 2-3 hd/tank x 3 tanks) of peak flow in the main distribution line and provide 8 gpm peak flow to each tank when filling individually, while overcoming all the losses (elevation, friction, and minor losses) in the system.

How to Measure Flow and Pressure

In developing a grazing program where a new well and buried pipelines will be installed, the necessary flow rates and pressures can be incorporated into the system design. In measuring hydrant capacities there must be an understanding of well and hydrant static pressure and hydrant operating pressure. Static pressure is the measured pressure of the water in the water line and pressure tank when there is no flow. This is stored energy that when a valve is opened the energy is converted into water flow. The higher the static water pressure the more energy in the system to overcome friction, minor, and elevation losses. Hydrant operating pressure is the pressure at the hydrant when a valve is opened downstream of the hydrant. It is measured pressure at the point of the pressure gauge while water is in motion. Since pressure is the restriction of flow, a full potential flow of the hydrant would indicate a near 0 psi pressure reading (valve fully open). When the tank's valve is nearly closed with minimal flow then the pressure gauge would read near static pressure.

There are two types of pressurized water systems: a variable-pressure pump with a pressure tank (pit or pitless) or a variable-frequency-drive (VFD) pump with a comparatively small pressure tank. Variable-pressure pumps operate within a switchable pressure range, such as 50 – 70 psi. A well with a VFD pump will vary motor speed to keep the water pressure constant as the flow rate changes. Methods for measuring the pressure and flow of these two pump systems are basically the same except that with the variable-pressure pump, measurements need to be made over the pressure range of the pump.

In existing systems the flow and pressure available with older wells and hydrants need to be measured to assess the capacity for filling portable tank. The first step in designing a portable water system is to do a pressure and flow check on each hydrant that will be connected to the surface tubing and portable tank. Pressure is a restriction of flow. For a given system, the higher the operating pressure the lower the flow rate and vice versa. Each hydrant will have different flow and pressure characteristics because the hydrants are at different elevations and different distances from the well. Before purchasing tubing or portable fencing, know the capacity of the well at each hydrant.

Figure 15 shows an assembly for measuring hydrant operating water pressure and flow from a hydrant. The pressure gauge and valve will simulate the flow capacity of the hydrant by adjusting the hydrant flow rate via opening or closing the valve and monitoring the measured pressure with the flow. Closing the valve and restricting water flow simulates the energy used to push the water in the proposed tubing length (friction and minor losses) and elevation loss or gain.

This assembly is relatively easy to construct and to use to measure static pressure at the hydrant and flow rates at specific pressures. To build this assembly you will need:

- fitting from female garden hose to ¾" pipe
- ¾" tee (female)
- pressure gauge (0-150 psi)
- ¾" threaded male pipe coupling/nipple
- ¾" quarter-turn ball valve, and
- pipe tape or joint compound.

Also needed are a stop watch, 5-gallon bucket, notepad and pencil.

Figure 15. Assembly for measuring water pressure and flow rate from a hydrant. Photo credit Jason Gross.

Follow these steps to measure pressure and flow from constant- and variable-pressure wells:

1. Connect the gauge/valve assembly to the hydrant (as illustrated in Figure 15). Make sure other hydrants are not being used.
2. Measure high and low static pressures at the hydrant. Open the hydrant and the valve to let any air out of the system. Then, slowly close the valve and record the pressure. Variable pressure pumps usually have high and low settings with 20 psi ranges (30 – 50 psi or 50 – 70 psi). Open the valve and drain the pressure tank for a while so the well engages. Then close the valve completely and record the pressure. Repeat once the pressure tank reaches high-pressure setting. Note: the difference between pressure at the well and at the hydrant indicates the extent of losses between the well and the hydrant.
3. Measure maximum flow rates. Use a stop watch to record the time it takes to fill a 5-gallon bucket with the hydrant and valve fully open. Use Table 4 to determine the flow rate in gpm. Do this at low and high pressure setting for variable pressure wells. The minimum required flow rate to the tank must be achievable when the switch is at the low pressure setting. When the valve is opened the operating pressure will drop to near the same pressure for both the low and high pressure settings, but there will be a difference in flow rate.
4. Measure the flow at intermediate pressures. The idea here is to see how the water delivery system responds as the system pressure changes. Open the ball valve and then slowly close it until about 10 psi registers on the pressure gauge. Then, record the pressure and the time it takes to fill the 5-gallon bucket. Repeat at 20 psi and additional 10 psi increments until the valve below the pressure gauge is fully closed. Convert fill times to flow rates using Table 4. A gradual loss of flow until the pressure approaches its maximum at no flow (valve closed) is expected. If flow is noticeably or significantly reduced at low pressure, this is a warning that the water delivery system may not perform acceptably in practice, and any minor restriction or additional system draw may result in cattle not receiving enough water.

When measuring flow rate at the hydrant, there will be some variability in flow based upon whether the pressure tank is being refilled and pressurized by the pump. This variability is usually small and unavoidable.

Fill time (seconds)	Flow rate (gpm)		Fill time (seconds)	Flow rate (gpm)
300	1		27	11
150	2		25	12
100	3		23	13
75	4		21	14
60	5		20	15
50	6		19	16
43	7		18	17
38	8		17	18
33	9		16	19
30	10		15	20

Table 4. Equivalent hydrant water flow rate based upon time to fill 5-gallon bucket.

Example Basic Design

Here is a walk-through of a basic design for providing water to grazing stocker calves using a portable tank and an existing hydrant. Known values include:

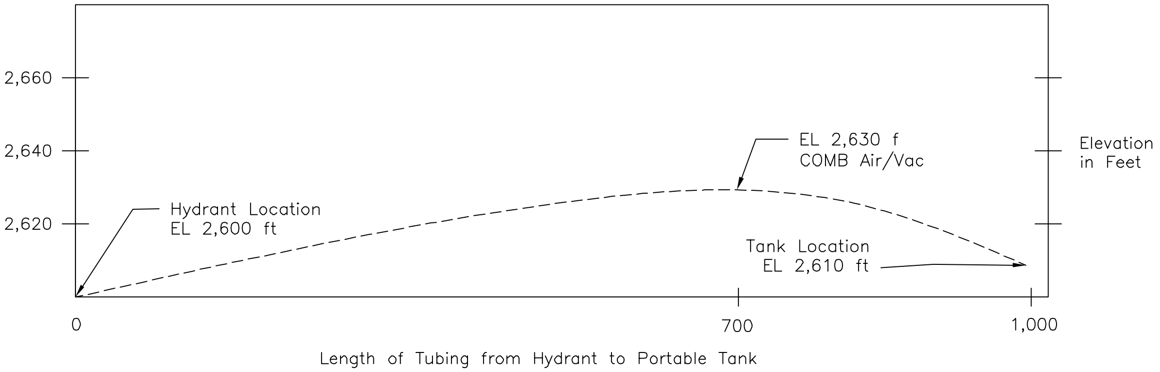
Water tank:
K-Line portable tank
One-time capacity: 4 calves

Elevations @ locations:
Hydrant elevation: 2,600 ft
Portable tank elevation: 2,610 ft @ 1,000 ft
Intermediate summit: 2,630 ft @ 700 ft

Tubing info:
Tube size: 1 ¼” or 1 ½”
Length: 1,000 ft from hydrant to tank

Well info:
Variable-pressure at 40 to 60 psi
(This is static pressure at the well)
Pitless well Whitewater Mfg.

Measured hydrant operating pressure verses flow at hydrant (Figure 14):
10 psi: 18 gpm
20 psi: 16 gpm
30 psi: 14 gpm
40 psi: 12 gpm
50 psi: 8 gpm



1. Calculate minimum required flow rate

   Peak demand at tank = 4 calves x 2 gpm/head = 8 gpm
   This means minimum required supply to the tank = 8 gpm

2. Evaluate Total Dynamic Head (TDH) at minimum required flow rate

   In this example there is only one hill or summit in the layout. In some installations, the length of tubing may traverse several hills and valleys between the hydrant and tank. Each major rise or fall must be evaluated for head loss or gain. In this example, the system must provide 8 gpm at the summit of the hill at 700 feet, so we need to calculate friction loss at the tank location (full length of the tubing) and also at the summit for each of the tube options.

   Friction loss: Trial 1 using 1 ¼” tubing:
   From Table 3, loss is 1.157 ft / 100 ft of tubing at 8 gpm
   To the tank: (1,000 ft / 100 ft) x 1.157 ft = 11.57 ft or 11.6 feet of friction loss
   To summit: (700 ft / 100 ft) x 1.157 ft = 8.099 ft or 8.1 feet of friction loss

Friction loss: Trial 2 using 1 ½" tubing:

From Table 3, loss is 0.5431 ft / 100 ft of tubing at 8 gpm

To the tank: (1,000 ft / 100 ft) x 0.5431 ft = 5.431 ft or 5.4 feet of friction loss

To summit: (700 ft / 100 ft) x 0.5431 ft = 3.8017 ft or 3.8 feet of friction loss

Minor loss: In this example there will be an air/vacuum vent at the hydrant, a COMB valve at the apex of the hill, three camlock fittings, and the fitting connecting the K-Line tubing to the hydrant, for a total of six flow interruptions. A conservative estimate of minor losses is:

0.5 ft / fitting x 6 fittings = 3 feet of minor loss

Elevation loss or gain: The elevation losses to lift water to the summit and to the tank are:

Summit El. – hydrant El. = 2,630 ft – 2,600 ft = 30 ft of elevation loss at summit

Tank El. – hydrant El. = 2,610 ft – 2,600 ft = 10 ft of elevation loss at tank

Pressure head available at hydrant: In this case, the desired flow rate of 8 gpm is achievable from the hydrant at 50 psi. Convert this pressure to feet of head.

50 psi x 2.31 ft/psi = 115.5 feet of head

Total dynamic head: The total dynamic head left at a given location to move water is calculated by subtracting the losses from the hydrant head pressure.

TDH = Head at hydrant – Friction loss – Minor loss – Elevation loss or gain

Trial 1: using 1 ¼" tubing

At the tank: 115.5 ft – 11.6 ft – 3 ft – 10 ft = 90.9 ft,

which at 2.31 ft/psi = 39.35 psi or 39 psi at the tank

At the summit: 115.5 ft – 8.1 ft – 3 ft – 30 ft = 74.4 ft,

which at 2.31 ft/psi = 32.2 psi or 32 psi at the summit

Trial 2: using 1 ½" tubing

At the tank: 115.5 ft – 5.4 ft – 3 ft – 10 ft = 97.1 ft,

which at 2.31 ft/psi = 42.03 psi or 42 psi at the tank

At the summit: 115.5 ft – 3.8 ft – 3 ft – 30 ft = 78.7 ft,

which at 2.31 ft/psi = 34.07 psi or 34 psi at the summit

In this case, we don't see much difference between the two tubing sizes (Trial 1 vs. Trial 2). This may be due in part to selecting tubing that is at least two sizes larger than the minimum size (¾" from Table 3). It is recommended to have a minimum of 10-15 psi available at a COMB air/vacuum vent and at the tank even though most COMB air/vacuum vents have a working range of 2 – 150 psi. In this case, we are well above the minimum at both locations, so either size of tubing will work. In order to complete the design a review of flow performance will have to be completed at the low side of the pressure switch.

3. Evaluate Total Dynamic Head (TDH) at low-pressure setting
   If the well is variable-pressure, then evaluate the TDH available at the low pressure setting (40 psi at the pressure tank). The system needs to function acceptably in the lower pressure range and higher flow rate. There is pressure loss in the system as water travels from the pressure tank to hydrants. This loss is normally determined as the difference in tank and hydrant static pressures. For this example, let's assume this loss is 10 psi or that the static pressure is 30 psi at the hydrant when the pump is switched to the low pressure setting (40 psi – 10 psi = 30 psi). At 30 psi, the flow rate from the hydrant is around 14 gpm, which leads to the following new friction losses:

Friction loss: Using 1 ¼" tubing:

From Table 3, loss is 3.2614 ft / 100 ft of tubing at 14 gpm

At the tank: (1,000 ft / 100 ft) x 3.2614 ft = 32.614 ft or 32.6 feet of friction loss

At the summit: (700 ft / 100 ft) x 3.2614 ft = 22.830 ft or 22.8 feet of friction loss

Pressure head available at hydrant: Now, 14 gpm from the hydrant is achievable at 30 psi.

Converting this pressure to feet of head:

30 psi x 2.31 ft/psi = 69.3 feet of head

Total Dynamic Head (TDH) – Using 1 ¼" tubing

At the tank: 69.3 ft – 32.6 ft – 3 ft – 10 ft = 23.7 ft,
which at 2.31 ft/psi = 10.26 psi or 10 psi at the tank

At the summit: 69.3 ft – 22.8 ft – 3 ft – 30 ft = 13.5 ft,
which at 2.31 ft/psi = 5.8 psi or 6 psi at the summit

The recommended pressure minimum for the tank valve and the COMB valve is 10 – 15 psi. The low critical valve pressures calculated for this scenario suggest that the system would barely function with the hydrant delivering 30 psi and 14 gpm.

Friction loss using 1 ½" tubing at 30 psi and 14 gpm:

From Table 3, loss is 1.5394 ft / 100 ft of tubing at 14 gpm

At the tank: (1,000 ft / 100 ft) x 1.5394 ft = 15.394 ft or 15.4 feet of friction loss

At the summit: (700 ft / 100 ft) x 1.5394 ft = 10.776 ft or 10.8 feet of friction

Total Dynamic Head (TDH) - Using 1 ½" tubing at 30 psi and 14 gpm:

At the tank: 69.3 ft – 15.4 ft – 3 ft – 10 ft = 40.9 ft,
which at 2.31 ft/psi = 17.7 psi or 18 psi at the tank

At the summit: 69.3 ft – 10.8 ft – 3 ft – 30 ft = 25.5 ft,
which at 2.31 ft/psi = 11.04 psi or 11 psi at the summit

At the low pressure setting, the 1 ½" tubing provides 5 psi more reserve at the summit than the 1 ¼" tube. With reserve of 11 psi instead of 6 psi, the COMB air/vacuum vent at the summit would be more likely to perform as expected. Note that the water flow rate to the tank will only reach its potential of 14 gpm when the tank valve is fully open (i.e. tank is refilling after being emptied or cattle have quickly lowered the water level). Most of the time the system would operate at a lower flow rate since as the cattle drink the valve will crack open and fill the tank. If the valve manages to compensate flow for how fast the cattle are drinking, then we would expect a much lower flow rate (8 gpm or less). This would indicate that the 1 ¼" tubing would work fine. Care and good judgement must be used to determine tube size. Other options would be to not have the tubing on top of the summit but to go around it at a lower elevation or to use 1 ½" for part of the line starting at the hydrant to the summit and then switch to 1 ¼" tubing. Dynamics in portable water systems can make the design rather difficult at times.

Moving surface tubes and portable tanks

It is essential that the equipment selected for providing water to intensive grazing areas be very portable and designed for the intended use. Moving tubing and portable tank needs to be simple to do with an ATV or other utility vehicle. The portable tank shown in Figure 16 can be moved while the tubing is still connected and pressurized; the tow hook on the stainless steel tank is simply connected to the ATV and the tank is ready to move.

A little foresight when laying out paddocks and extra care when moving tanks should minimize flow problems and maximize tube life. When tanks are moved, make sure that the tubing won't cross itself so that it could pinch itself off. With a little practice, moving tubing from one paddock to the next should become very simple.

Sometimes, narrow gates, roads, or other obstructions can complicate the move. In these situations, it may be quicker and easier to disconnect the tubing at the cam-lock connections and tow the individual sections. In Figure 17, sections of tubing have been secured to be towed through a narrow gate. A simple clove hitch connection with a rope is a quick and easy way to secure tubing for transport. Always use a rope or a strap and not a chain to move tubing. Chain or cable will girdle the tubing and damage it.

Figure 16. Portable tank about to be towed to a new location. Photo credit Jason Gross.

Figure 17. Securing tubing with a tow rope and clove hitches. Photo credit Jason Gross.