Livestock Watering
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture and Lands

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LIVESTOCK WATER SYSTEM DESIGN #3

Calculating Pumping Requirements

This Factsheet outlines how to determine pump and pump motor requirements for a livestock water system.

Water Pumping

When water must be raised above the supply point, or pressurized to supply a trough, etc, energy must be supplied by a pump to do so. There are many pump types and many energy possibilities as outlined in ***Factsheet #590.305-1 to #590.30-10*** in this ***Livestock Watering Handbook*** series.

What Must A Pump Do?

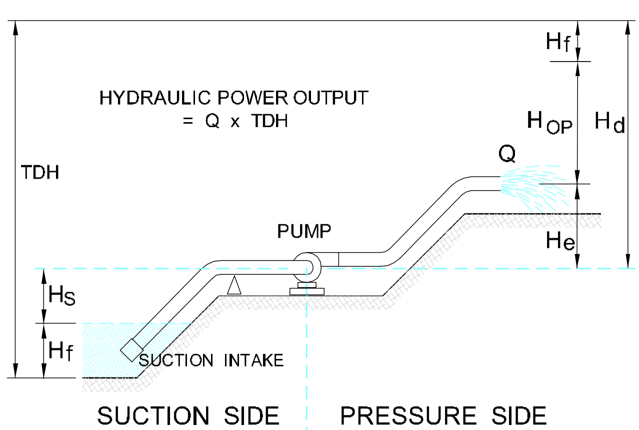
A pump must be selected to do a specific job for the watering system which has two components (refer to Figure 1, below):

- provide water at a flow rate (Q)
- lift a quantity of water from the source to the trough plus pressure (L)

Flow Rate 'Q'. This is the water flow rate calculated in ***Factsheet #590.304-1*** for the livestock being watered, in US gallons per minute (USgpm).

Lift 'L'. Also known as the Total Dynamic Head (TDH); it is the total (in feet) of:

- pump suction side – lift and friction
  - Hs (lift - distance from the water to centre of the pump) + Hf (friction)
- pump pressure side – lift, friction and operating pressure = Hd (discharge head)
  - discharge head (He) – elevation from the pump to the highest system point
  - friction head (Hf) – the total friction loss of all discharge fittings and pipe
  - pressure head (Hop) – the operating pressure required in the system



Hydraulic Power Output 'P' This is flow (Q) x total head (TDH) and is the energy the pump motor must provide. (see Pump Motor Horsepower, page 3).

Figure 1 Pump Terms Describing Suction, Head and Power

Note: pressure can be expressed as pounds per square foot (psi) or feet of head (ft)

- 1 psi = 2.31 feet of head
- 1 foot of head = 0.433 psi

Pump Suction Lift Limitations

Ninety percent of all non-submersible pump operation problems are on the suction side of the pump. Pumps create a lower-than-atmosphere pressure in the suction line and rely on atmosphere pressure to move water up into the pump. For the pump to be able to operate, the suction losses must be less than the atmospheric pressure available at the pump or water will not be available to the pump to pressurize.

The atmosphere pressure at the pump depends on the elevation above sea-level. As higher elevations have reduced atmospheric pressure, the suction ability of pumps is reduced at these elevations, as shown by the following Table. Note that this does not apply to submersible pumps (e.g., well pumps) as they have flooded intakes.

Suction Lifts [1] (ft)

Altitude above Sea Level (ft)	Air Pressure (psi)	Practical Suction Lift of Pump [2]	
		displacement	centrifugal [3]
0 (sea level)	14.70	22.0	15.0
500	14.40	21.5	14.5
750	14.30	21.3	14.3
1000	14.20	21.0	14.0
1250	14.00	20.7	13.8
1500	13.90	20.5	13.5
1750	13.80	20.3	13.3
2000	13.60	20.0	13.0
3000	13.20	19.0	12.0
4000	12.60	18.0	11.0

[1] does not apply to submersible pumps as they have a flooded suction

[2] practical suction lift is equal to the vertical distance (ft) from the water surface to the centre of the pump plus all friction losses in the suction pipe and fittings

[3] note the relatively poor suction abilities of centrifugal pumps

Pump Total Lift

Having satisfied the suction requirements, the next step is the discharge lift of the pump. This is the highest elevation above the pump that water must flow to, and can usually be measured with an altimeter, eye-level, or surveyor's level. There is usually no need for a high degree of accuracy – a handheld GPS (global positioning system) instrument measuring to the nearest metre is sufficient.

For most livestock watering systems the discharge lift is the largest part of the TDH. The other parts (suction, pressure, and friction) are usually small.

The following "rule-of-thumb" can be used for **initial estimations** of the pump needs of 'simple' systems **that do <u>not</u> have** extensive piping distances. Proper pipe sizing to reduce friction losses is assumed – refer to ***Factsheet #590.304-2***.

Pump Lift "Rule-Of-Thumb" for Initial Estimations

PUMP TOTAL LIFT = ELEVATION TO HIGHEST POINT + 100 FT *
(* 100 ft allows for 30 psi at the trough + 30 ft suction, lift, & friction loss)

Note this is **only** for system estimation – actual system conditions must be determined (as in the following example) for an actuate pump lift requirement.

Pump & Motor Selection

With both the flow rate (from ***Factsheet #590.304-1***) and the total lift (estimated above or calculated as in the following example), a pump can be selected (refer to ***Factsheet #590.305-2*** for pump types). But a pump must be powered; both pump and pump motor should be selected to 'match' each other.

Pump / Motor Units. For the small size of many livestock watering systems, the pump used may be integral with a motor. In other words, pump specifications will include proper motor sizing.

Separate Pump / Motors. Larger pumps are selected for their capacity and then a separate motor is selected to power the pump. Ensure the motor has the ability to start the pump, as some pumps have a high startup power requirement. Also ensure the motor can be run for whatever continuous period of time the watering system requires.

Energy Source. The energy source available at the livestock watering site will limit the motor options (refer to ***Factsheet #590.305-1***). System efficiency is more important when the energy source is, say solar, then when using the electrical grid.

Pump Motor Horsepower

In selecting a pump motor, the horsepower must be calculated that is required to power the pump to provide the determined flow and lift.

The pump motor horsepower requirements for a particular site can be calculated using the following formula:

$$\text{Horsepower (hp)} = \frac{\text{Flow Rate (Q in USgpm)} \times \text{Total Lift (TDH in ft)}}{3960 \times \text{Pump Efficiency}}$$

- 3960 is a conversion for the different units
- pump efficiency is entered as a decimal (e.g., 65% is entered as 0.65)
- if the pump efficiency is not known, choose a conservative 50%
- the horsepower calculated must be 'rounded-up' to a standard motor size (e.g., a calculated 0.8 hp would be rounded-up to 1 hp)

The Example on the next page shows how this equation is used to calculate a pump motor horsepower.

Example - Pump and Pipe Sizing

From ***Design #1 Factsheet #590.304-1*** a herd of 100 beef cow-calf pairs will graze a pasture with a water trough. A stock watering system is being developed that requires a flow rate of 7.5 USgpm and a minimum pressure of 22 psi at the trough. From ***Design #2 Factsheet #590.304-2***, page 7, the Pump System Example had a source of water located 100 ft below the trough location and required 2000 ft. of piping. Either 1 or $1\frac{1}{4}$ inch polyethylene pipe could be selected. The pump sizing was to be done to finalize the pipe size.

QUESTION **What pump motor size is required for these two pipe sizes on this site ?**
And knowing the motor sizes, which pipe size is preferred ?

- information given: 7.5 USgpm at 22 psi pumped up a lift of 100 ft through 2000 ft of pipe

- calculate the total lift required for each of the twp possible pipe sizes:
  - total lift (head) the pump must provide is:
    assume suction head of 10 ft
    discharge head is 100 ft
    pressure head (at the trough) is 22 psi x 2.31 = 51 ft
    friction head (loss) is 74 ft for 1 inch and 20 ft for $1\frac{1}{4}$ pipe (from *Factsheet #590.304-2*)
    for 1 inch = 10 ft + 100 ft + 51 ft + 74 ft = **235 ft total lift**
    for $1\frac{1}{4}$ inch = 10 ft + 100 ft + 51 ft + 20 ft = **182 ft total lift**

- calculate the required motor horsepower to power the pump

$$\text{Horsepower (hp)} = \frac{\text{Flow Rate (USgpm)} \times \text{Total Lift (ft)}}{3960 \times \text{Pump Efficiency}}$$

for 1 inch pipe, $hp = \frac{7.5 \text{ USgpm} \times \mathbf{235\ ft}}{3960 \times 0.50} = 0.89$ hp round-up to **1 hp**

for $1\frac{1}{4}$ inch pipe, $hp = \frac{7.5 \text{ USgpm} \times \mathbf{182\ ft}}{3960 \times 0.50} = 0.69$ hp round-up to **0.75 hp**

- the two pipe sizes that where selected from the ***Design #2 Factsheet #590.304-2*** example require two different motor horsepower sizes

ANSWER

- **either pipe size could be selected depending on the type of energy source available, eg:**
  - **grid electric energy source – either motor size as electrical operation costs are not high**
  - **solar energy source – choose the larger $1\frac{1}{4}$ inch pipe as solar energy costs are usually high and a smaller motor in a system with lower friction losses is preferred**

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