BRITISH COLUMBIA
Ministry of Agriculture and Lands

Order No. 590.307-3
January 2006

WINTER OUTDOOR LIVESTOCK WATERING

It's all about the Energy Choices

This Factsheet outlines options for livestock watering in winter conditions with some ideas and pointers for successful systems. Various energy choices are discussed.

Water or Snow ?

Because of the difficulties of providing water in winter in many areas of B.C. snow is sometimes considered as a water source. Research in Alberta has shown cows can substitute snow for water without any detrimental effects. A trial with calves fed hay and grain showed slightly less weight gain than calves with water. Although eating snow should require more energy than drinking water, these trials on cows and calves showed little differences. However, quality and quantity of snow is important :

- 10 to 12 inches of snow may have to be melted to get 1 inch of water
- fluffy snow may be preferred by livestock but it has a low water content
- 'crusted' snow may be difficult for livestock to use
- some areas may not have sufficient snow some winters
- pens areas or small fields may not have sufficient clean snow to use

The use of snow as a livestock water supply remains an individual decision. The assumption of this Factsheet is that water will be supplied via some form of waterer and snow used only as an emergency water supply.

The Winter Water Problem

As we all know, liquid water becomes solid ice at or about zero degrees centigrade. Two things are actually happening :

- water expands by about 9% as it freezes into ice
- the ice is about 8% lighter (less dense)

Besides the water becoming solid and therefore not available to livestock, the expansion property of freezing water causes the physical damage to watering system components such as broken water lines, float valves, etc.

Refer to Factsheet #590.307-1 for details on winter considerations.

The Solutions

Of course the solution to this problem is simple - provide energy (as heat) :

1. **Supply Heat** to keep the water from freezing (refer to pages 3 - 7)
2. **Reduce Heat Loss** to prevent heat from escaping (refer to page 9)
3. **Combinations** of these two solutions (refer to pages 9 - 11)

And of course these solutions may be easier said than done and have a cost.

LIVESTOCK WINTER WATERING OPTIONS - A SELECTION CHART

SNOW ??

Livestock eat snow
- -10-12 inches needed for 1 inch water
- -fluffy snow has little water
- -'crusted' snow hard to access
- -is there sufficient clean snow?

or

WATER ??

Livestock access watercourses
- -uncontrolled, controlled, or improved

Water is moved to the livestock
- -requires frost-proof waterers

OPTIONS TO FROST-PROOF WATERERS

REDUCE HEAT LOSS

Heat loss can be reduced by
- -using a small open bowl area
- -insulating the walls
- -having a good seal at the concrete pad

OR

SUPPLY HEAT

ON-SITE HEAT — ***Use heat already on the site***

Earth Heat
- -earth stored water
- -heat riser pipe

or

Water Heat
- -"energy free" waterers
- -flow-through waterers

or

Solar Heat
- -limited direct heat
- -with a windbreak?

OFF-SITE HEAT — ***Bring heat to the site***

Wood Heat
- -"batch" heat
- -must tend
- -low cost

or

Petroleum Heat
- -propane
- -automatic

or

Electric Heat
- -most common
- -safety concern
- -wire cost limits distance

or

Gas "Bubbler"
- -propane bottle
- -gas expansion circulates water

OR

COMBINATION OF BOTH REDUCE HEAT LOSS & SUPPLY HEAT

1. SUPPLY HEAT TO THE WATERER

There are a number of possible heat energy sources that may be used for livestock waterers. These may be categorized in two ways.

1. Energy available 'free' at the waterer :
   - earth heat that warms an in-ground extension of the water bowl
   - earth heat that warms the supply water
   - earth heat in the air column of the "heat rise pipe" below the waterer that can circulate from below frost level up to the bottom of waterer
   - solar heat that the waterer may be exposed to

2. Energy that may be 'supplied' to the waterer :
   - wood - burnt in a heater
   - propane - gas fired heater or 'bubbler' water circulation
   - electrical - element heater

Energy Available 'Free' At The Waterer

Earth Heat

The surface of the earth looses heat as the atmosphere cools in winter to a point where the earth freezes (depending on moisture content, compaction, etc.). The depth of this frost is related to the local climate (degree days) and varies from less than 2 feet on the Coast, to 4 feet in the Southern Interior, to 6 feet or greater in the Central and Peace areas. Below these depths the earth has heat which can be used to assist in protecting a waterer from freezing.

"Earth-Stored" Water. Waterers that have a special large, in-ground extension of the water bowl (refer to Figure 1, below) use earth heat. This 'bowl water' will develop a convection current that will transfer heat from the deep, earth-warmed water, up to the bowl surface replacing the air-cooled surface water. The cooled water in turn falls to the bottom of the 'bowl' to be warmed and re-circulated.

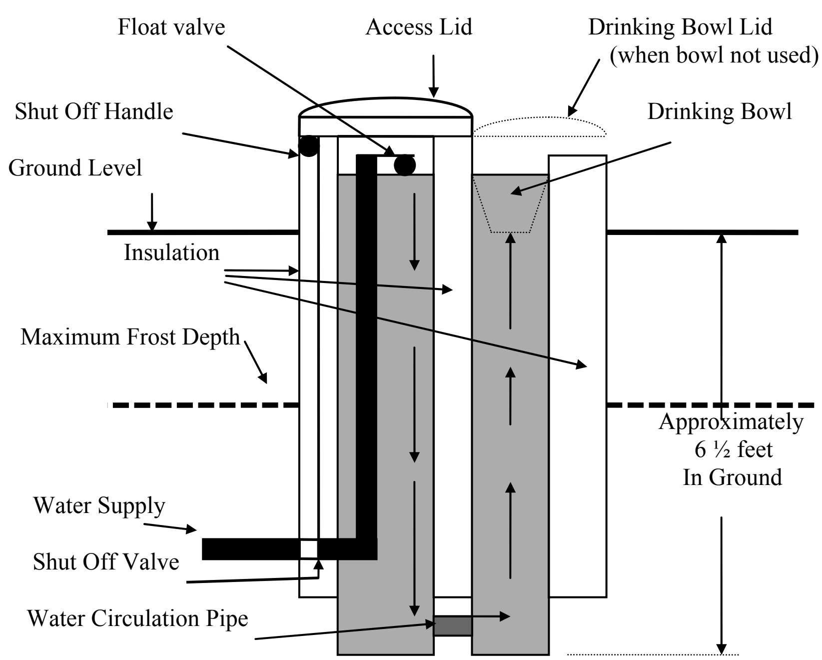


Figure 1

Commercial "Earth-Heated" Waterer

(not to scale)

Heat Riser Pipe. The earth heat can be transferred from the earth via air (Figure 2, below). An air column or 'heat riser pipe' is set in the ground from 2 feet or more below frost level up to the underside of the waterer. The water supply line is run up this column to the waterer. The air in this column will develop a convection current, moving warm air up to the waterer where it will cool (giving off some heat) then fall to be re-warmed by the earth.

Research on the Prairies has shown that this column should be a minimum of 14 inches in diameter to be most effective. A good seal between the waterer, the base pad and the heat riser pipe is essential to prevent this heat being 'lost'. This heat supply should only be relied upon to keep the water supply line in the column from freezing. It likely will have only a small affect on the waterer itself.

Commercial heat riser pipes are available that have insulated walls for 2 to 4 feet. This insulated portion could be used in colder climates on the upper portion of the column. ***Never insulate across the inside of the column as this will block the warm air from the water line and may result in the line freezing***. An insulation sleeve around the supply pipe for the top 2 to 3 feet may be worthwhile. Alternately, an electrical 'heat tape' may be used.

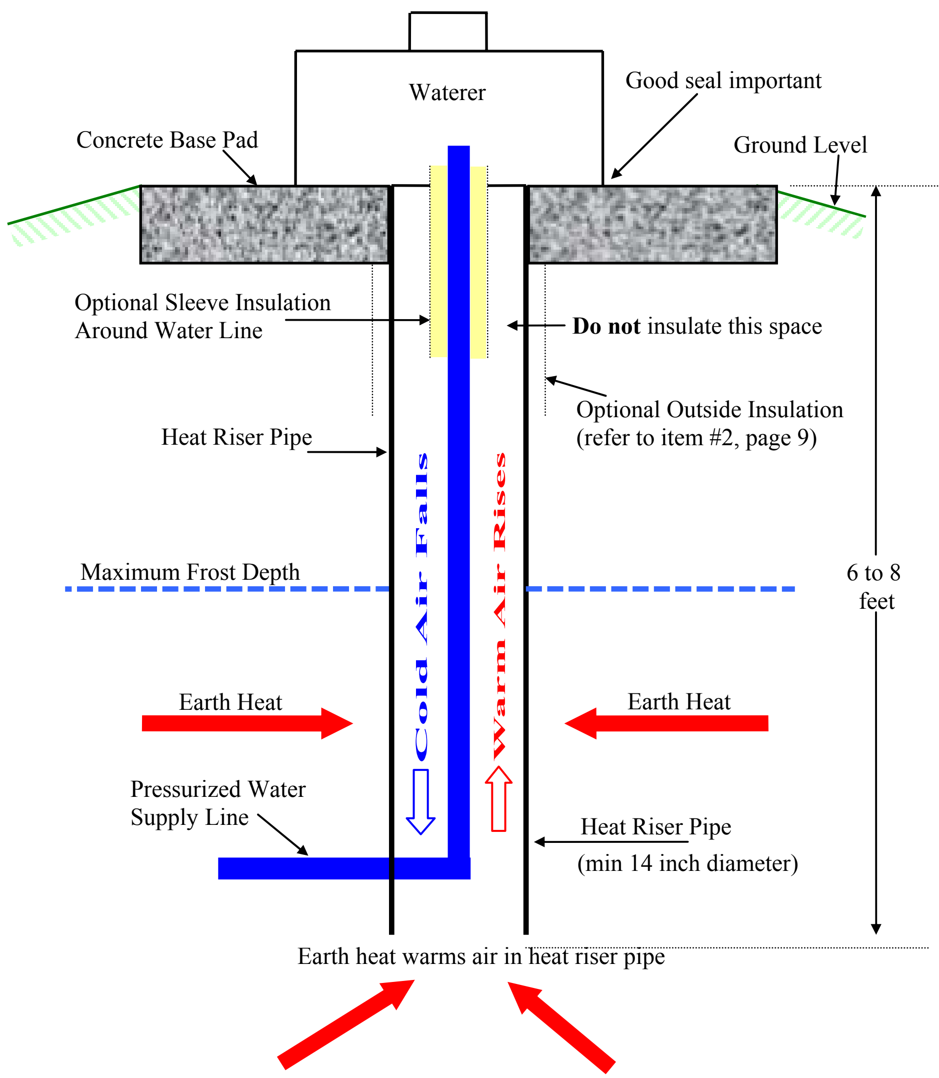


Figure 2

Heat Riser Pipe under a Waterer

(not to scale)

Water Heat

The water supply to the waterer comes piped through the earth and is warmed by it. This heat can be used to keep a waterer frost free, either by:

- insulating the waterer to retain heat as the water sits in the waterer bowl ("energy free" or highly insulated waterers); or
- flowing water through the bowl at a rate to match the heat lost from the waterer (flow-through waterers); or
- using a combination of both.

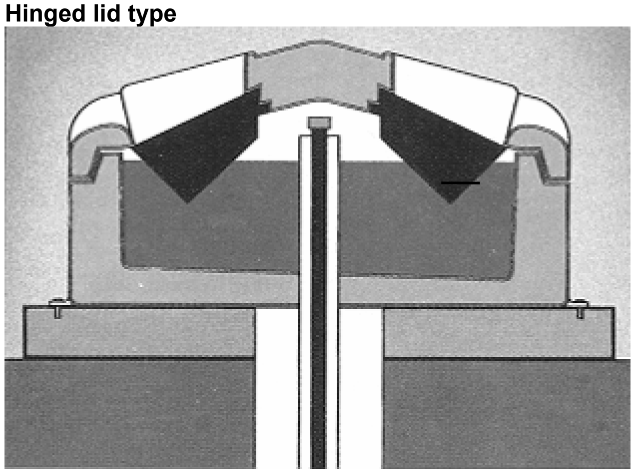
"Energy Free" Waterers. These are highly insulated waterers and use only the heat of the supply water to prevent freezing. Properly selected and installed, these waterers stay ice-free with only some minimal maintenance. They typically (refer to Figure 3, below) :

- have thick, well insulated walls
- may have walls of a "plastic" material with "foam" insulation
- may use some form of lid (floating or hinged) to cover the drinking area
- require livestock to push aside the lid for drinking
- ***must be sized for the livestock use*** (as this ensures proper water inflow to provide sufficient heat)

Figure 3

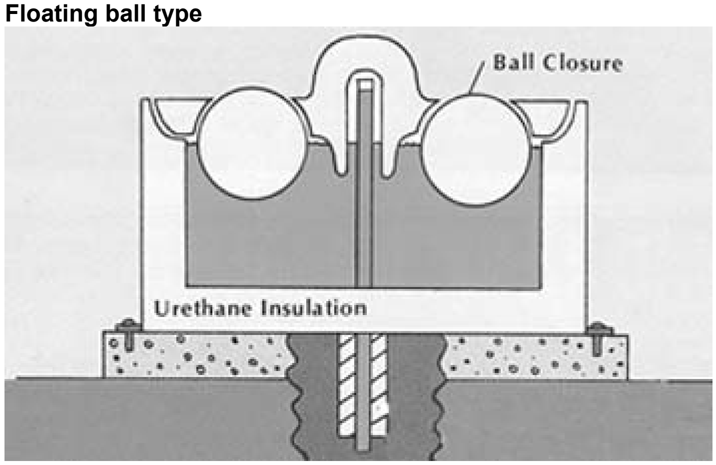
Typical "Energy Free" Waterers

Hinged lid type



(courtesy Superbowl by Superior Precast)

Floating ball type



(courtesy MiraFount by Miraco)

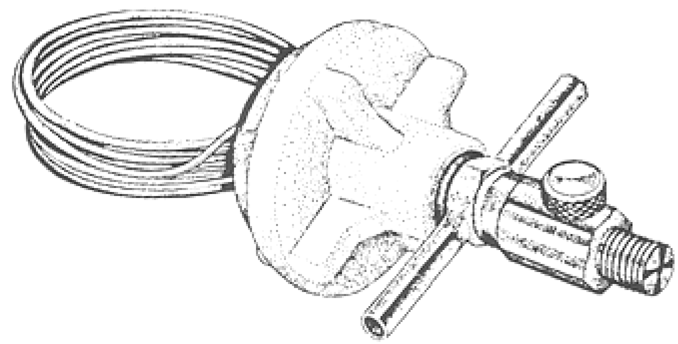
Flow-Through Waterers. These use the heat of the supply water to offset the heat lost from the waterer. Some Points to consider:

- is there sufficient water to “waste” as flow-through?
- can this “waste” water be handled and disposed of properly?
- or can this water be recirculated?
- if the water is pumped (ie. gravity flow not possible), is this less expensive than directly heating the water in the bowl?

The water flow-through may be constant, if weather conditions require, or it could be intermittent. An ‘Ice Preventer” valve (refer to Figure 4, below) is available that is installed prior to the float valve in a waterer. As the water cools, a sensor opens the valve flowing water into the waterer (this water will go out the waterer overflow line). As the water warms, the valve closes. The float valve works normally.

Figure 4

“Ice Preventer” Valve



(courtesy Walters Control Co.)

Selecting Flow-Through Rates. If a water flow-through design is to be used, a number of factors must be decided upon for a successful system. They include :

- the structural characteristics of the waterer, including:
  - the water surface area exposed to the air
  - the surface area of the walls
  - the insulation value of the walls
  - the water volume in the waterer
- the coldest winter air temperature at the waterer
- the wind conditions at the waterer
- the water temperature of the supply water
- the flow rate of the supply water

These factors in the selection tables available in Factsheet #590.304-6, ***Selecting Flow-Through Rates to Frost-Proof Water Troughs.***

Figure 6, page 11, illustrates a flow through waterer that uses a manually operated gate valve located prior to the float valve.

Solar Heat

This is the heat gained from direct exposure to the sun. In most cases this will be limited, but can be useful, especially when combined with a windbreak fence.

Energy 'Supplied' To The Waterer

Wood Heat

Waterers have been available that burn wood to heat the water bowl. This is a batch energy supply and must be regularly refilled.

Propane Heat

Waterers are available that have a thermostatic gas control valve and a pilot light. The burner ignites as the water cools. The burner heats up the area under the water bowl and gases exhaust around the edge of the bowl. A baffle-protected side panel lets in combustion air. The propane bottle can be set back from the waterer with a buried supply line running up the heat riser pipe with the water line. Protect the bottle from livestock.

Electrical Heat

The most common energy supply that is brought to a waterer is electrical :

- it is easy to use and automate;
- it is generally an economical heat source;
- but the costs of the supply system to a waterer may be excessive, depending on the distance to the waterer from the electrical supply.

Safety There is a safety concern when using electricity around water :

- install the waterer to the manufacturers' instructions and Electrical Code;
- as per Code, ground the waterer with a separate stranded copper ground conductor of at least number 6 American wire gauge (#6AWG) ***running from the waterer to the branch circuit supply*** (electrical panel); and
- consider "equipotential" grounding of the waterer to the concrete base pad rebar.

Estimating Wire Size. Before purchasing an electrically heated waterer find out the element wattage and calculate the wire size and cost. Table 1, next page, may be used to ***estimate*** the wire size to supply an electrically heated waterer - confirm with an electrician before purchase or installation.

Electrically heated waterers have different wattage elements. For example, a waterer sized for 60 to 75 cattle may have a 400 watt element whereas a larger one for 200 to 250 cattle may have a 1200 watt element.

Table 1 can be used knowing the wattage or amperage required for the waterer. Use the wattage and voltage to find the amperage draw of the element. The formula for amperage is : *amperage = watts / volts*. For the 400 watt element in a 120 volt circuit, divide 400 by 120 for a 3.3 ampere draw (use 4 amperes). The 1200 watt element would draw 10 amperes.

Secondly, measure the distance from the electrical panel to the waterer (in feet or meters). Lets say the distance is 200 feet. Using Table 1, the line at 4 amps/400 watts indicates a #14 AWG wire size (2 conductor copper wire) for 200 feet. For the larger waterer, a 10 ampere draw and 200 feet requires a #10 AWG (2 conductor copper wire).

Electric wire is available for burial and can be placed in the same trench as the water line. Consult an electrician for the Electrical Code requirements.

Table 1 ESTIMATING COPPER WIRE CONDUCTOR SIZES

(For 5 Percent Drop in Potential on 110-120 Volts Single Phase using 2 Single Conductors)

		Approximate Distance in Metres or *Feet* from the Waterer to the Electrical Panel																				
Meters		6	9	12	15	18	21	24	27	30	36	42	48	54	60	72	84	96	108	120	135	150
Feet		*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100*	*120*	*140*	*160*	*180*	*200*	*240*	*280*	*320*	*360*	*400*	*450*	*500*
amps	**watts**	**American Wire Gauge Number (AWG #) of 2 Single Conductor Copper Wire**																				
1	**120**	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
2	**240**	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	14	14	14	14	12
3	**360**	16	16	16	16	16	16	16	16	16	16	16	16	16	14	14	14	12	12	12	12	10
4	**480**	16	16	16	16	16	16	16	16	16	16	16	14	14	14	12	12	12	12	10	10	10
5	**600**	16	16	16	16	16	16	16	16	16	14	14	14	14	12	12	12	10	10	10	10	8
6	**720**	16	16	16	16	16	16	16	16	14	14	14	12	12	12	12	10	10	10	8	8	8
7	**840**	16	16	16	16	16	16	16	14	14	14	12	12	12	12	10	10	10	8	8	8	8
8	**960**	16	16	16	16	16	16	14	14	14	12	12	12	12	10	10	10	8	8	8	8	6
9	**1080**	16	16	16	16	16	14	14	14	14	12	12	12	10	10	10	8	8	8	8	6	6
10	**1200**	16	16	16	16	14	14	14	14	12	12	12	10	10	10	8	8	8	8	6	6	6
12	**1440**	16	16	16	14	14	14	12	12	12	12	10	10	10	8	8	8	6	6	6	6	6
14	**1680**	14	14	14	14	14	12	12	12	12	10	10	10	8	8	8	6	6	6	6	4	4
16	**1920**	14	14	14	14	12	12	12	12	10	10	10	8	8	8	6	6	6	6	4	4	4
18	**2160**	14	14	14	14	12	12	12	10	10	10	8	8	8	8	6	6	6	4	4	4	4
20	**2400**	14	14	14	12	12	12	10	10	10	8	8	8	8	6	6	6	4	4	4	4	2
25	**3000**	12	12	12	12	10	10	10	10	8	8	8	6	6	6	6	4	4	4	2	2	2
30	**3600**	10	10	10	10	10	10	8	8	8	8	6	6	6	6	4	4	2	2	2	2	2

Table derived from Table D3 and Note 7 of the Canadian Electrical Code (Courtesy Saskatchewan Agriculture)

Importance of Wattage. Table 1 indicates how important the wattage size of an element is, especially when long distances separate the electrical supply and the waterer. For long distances, the 240 volt elements will be attractive as they draw lower amperages and will require smaller (less costly) wire sizes.

If a waterer is electrically heated, a heat tape may be used for the upper portion of the water supply pipe just below the waterer base pad. Then a smaller diameter riser pipe may be used in place of the 14 inch diameter heat riser pipe (shown in Figure 2, page 4). However, using the smaller pipe is a small installation cost-saving with a loss of the earth heat benefits (which remain even if the power goes off!) and, as the wattage of a heat tape must be included in the wire size calculation (element wattage plus heat tape wattage to estimate the full amperage draw), it may increase the wire size and cost.

Propane "Bubbler"

Where a pond or large trough is freezing over, a "gas-bubbler" device may be used that circulates the warmer, lower level water up to the surface, keeping a watering hole open. A submerged propane bottle (about 5 lb size lasts 3 months) is hose-connected to the bubbler devise which very slowly releases the gas, creating circulation. It is not a safety concern as little gas is released at a time. (*Currently this device is not available; it is mentioned here in the expectation that it will be available again.)*

2. REDUCE THE HEAT LOSS OF THE WATERER

Besides supplying heat to the waterer, frost protection is increased when the heat loss is reduced. Heat loss from a waterer is due to a number of factors:

- structural characteristics of the waterer, a combination of;
  - the water surface area exposed to the air
  - the surface area of the walls and bottom
  - the insulation value of the walls and bottom
  - the water volume in the waterer
  - the minor losses between the waterer and it's base pad
- air temperature
- wind velocity across the open top of the waterer

The rate of heat loss increases as the temperature difference increases. This can be greater between the waterer and the air (which can be -40^{0} C or more in some parts of B.C.) than between the waterer and the earth. For this reason, insulation is usually most effective on the walls exposed to the air. However, ***the greatest heat loss is usually from the water surface in the open bowl.***

Heat loss can be reduced by :

- selecting a waterer that has as small a bowl surface area as possible for the livestock numbers
- insulating the walls of the waterer (e.g., use a foam type material not affected by moisture and protected from livestock chewing, etc.)
- ensuring a good seal between the waterer and the mounting pad (using a strip of plastic sill plate gasket will help make a good seal)
- using a windbreak to reduce the wind chill factor, where appropriate

Consider these heat loss factors when purchasing and installing a winter waterer to reduce the need or amount of added heat for frost proofing.

3. PUTTING IT ALL TOGETHER

The following are some selection ideas that can be used to best choose a winter waterer system for particular situations.

General

1. Setup the waterer with a heat riser pipe with the water supply line inside.

2. Use the Freezing Index to choose heat riser pipe insulation: for climates with greater than 600 Degree-Days Centigrade, consider insulating the outside top 2 feet of the heat riser pipe: in climates greater than 750 Degree-Days use 4 feet of insulation (refer to Factsheet #590.307-1 ***Winter Considerations of Livestock Watering***).

3. Install the waterer on a solid base pad (such as concrete); seal the joints between waterer, pad and riser pipe to prevent air movement (heat loss).

With Electricity

4. If electricity is available and if the wire size (from Table 1, page 8) is reasonable, install an electrically heated waterer.

5. If electricity is available but beyond a distance for 110/220 volt supply, consider a higher line voltage system using transformers at each end (voltage boosted at the supply and reduced to the heater voltage at the waterer) which will reduce amperage and therefore wire size and costs. *This must be done as directed by a qualified electrician.*

6. If electricity is available but the above options are not appropriate, consider pumping water for a flow-through waterer. This system would require the water source within reasonable distance of the electrical supply for the pump. Water lines would be trenched to and from the waterer (these should be less expensive than the electrical wire). The water could be re-circulated or piped to "waste".

Without Electricity

7. If electricity can't be used for heating as above, consider using propane or wood heaters. A pressurized water supply is required that would have to come from a separate energy source (that may mean electricity is still required at some point in the system or, if gravity can be used, consider point #8).

   A waterer that uses the "stop and waste" self draining principle of a Frost-Free Hydrant (refer to page 12) but is turned on and off by the livestock themselves is illustrated in Figure 5, next page, sold for horses use under the name "Drinking Post". It requires energy for the pressurized water supply (min. 45 psi) but not for any heat energy. This type of waterer could also be of some advantage in summer as algae should not grow in the bowl as it is empty when not being used.

With Gravity Water Supply

8. If a gravity pressured water supply is available consider :
   - if the source is above the waterer, using this as the pressure supply for any type of heated waterer; or
   - if there is sufficient volume, using it as a pressure supply and flow-through for heating the waterer as in Figure 6 (note that flow-through water can be plumbed to one or more waterers, in parallel or series, depending on water temperature and volume); or
   - if the source is below the waterer, use the gravity flow to power a hydraulic ram pump to supply the waterer (waterer pressure supply only or plus flow-through) - note rams pump only about 10% of the water supply – refer to Factsheet 590.305-5, ***Using Gravity Energy to Pump Livestock Water.***

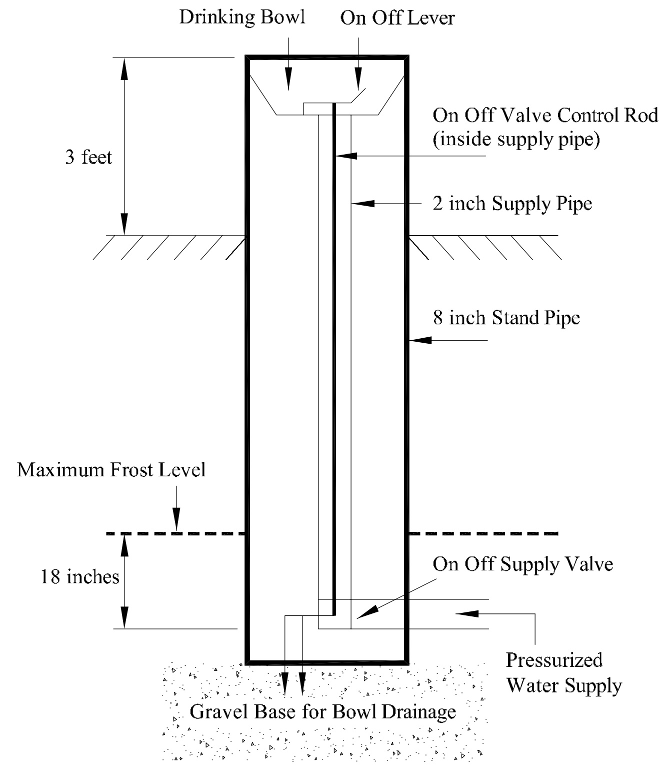
Without Gravity Water Supply or Electricity

9. If there is neither an electrical supply nor a gravity supply possibility, a pumping and heating system must be setup that uses the other energy sources, such as :
   - solar energy (as either wind or photovoltaic electric) for pumping, possibly with flow-through frost protection (although for photovoltaics, that requires extra, hard-to-get winter solar pumping energy) or in conjunction with a wood or propane heater.

Figure 5

Self Draining "Drinking Post"

(not to scale)

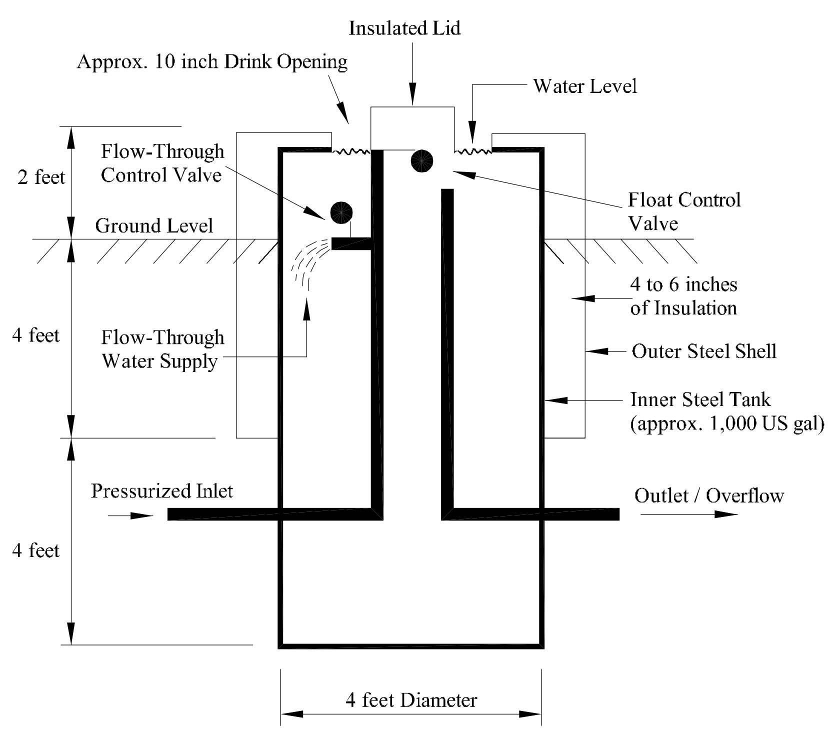


When the lever is off, the supply pipe drains down to the supply valve.

Figure 6

Chutter Ranch "Flow-Through" Design

(not to scale)



Note this trough has heat supplied with flow-through water combined with wall insulation and small water surface area for reduced heat losses. It may be used as a float controlled waterer or as a flow-through one.

Random Pointers

The following are a few pointers for winter watering systems.

The Freezing Index. This can be used to estimate frost penetration and ice thickness as well as choosing insulation for the outside of heat riser pipes. Refer to Factsheet #590-307-1, ***Winter Considerations of Livestock Watering***.

Frost-Free Hydrants. A water trough may be filled on a daily basis using a yard frost-free hydrant. This device has an above ground on/off handle which operates a below ground "stop and waste" valve on the water supply. When opened, this valve directs water to the surface outlet (which could empty into a trough). When closed, it allows the riser pipe to drain into the ground back to the depth of the supply line, which is below frost. Refer to Factsheet #590.307-2, ***Frost Free Hydrants***.

System Shut Off. All waterers, regardless of how they are heated, require a shut off of the pressured water supply. A buried "stop and waste" valve may be used that is located below frost and activated by a rod above ground.

System Drain. If a "stop and waste" valve (self-draining) is not used, provision should be made to drain both the supply line above the frost level and the waterer.

"Wind Chill". This is the effect created when wind increases *the rate of heat loss* (in everything, including livestock and waterers), making the air feel colder than it actually measures. A waterer will not be cooled below the actual air temperature (the air temperature is *not* lowered with the wind), but, as the wind increases the rate of heat loss, the heat supply may need to be increased.

For example, a waterer in -10^{0}C air may be frost proof with a given heat supply. Should the wind blow at, say 40 kmph, the heat loss from the waterer may be the same as if the air were, say -30^{0}C. The waterer would not cool below the actual -10^{0}C air temperature, but it would be cooling quicker. The heat supply may have to be increased to keep the waterer from freezing.

Well designed waterers should be able to supply heat for these conditions. Thermostats may have to set higher than normal during long windy periods. Portions of the supply line, float valve, or other components that normally don't freeze may freeze in windy conditions.

A windbreak fence will reduce the "wind chill" effect. As snow is often moved with wind in winter, a windbreak may "gather" snow so the two must be considered together.

Other Information

Check local irrigation and general farm suppliers for equipment described.

RESOURCE MANAGEMENT BRANCH
Ministry of Agriculture and Lands
1767 Angus Campbell Road
Abbotsford, BC V3G 2M3 Phone: (604) 556-3100

WRITTEN BY
Lance Brown
Engineering Technologist
Kamloops Office