Livestock Watering
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture and Lands

Order No. 590.307-1
January 2006

WINTER CONSIDERATIONS

Ice Formation, Freezing Index, and Frost Penetration

This Factsheet outlines winter considerations of on-farm livestock water sources and water systems.

Ground Water

Frost protection for ground water systems is usually for the water line from the well. The use of pitless adapters provides for a frost-free connection between the well and the buried line. Refer to Factsheet #590.303-2, ***Accessing Ground Water Sources***.

Surface Water

Intakes in surface water such as springs, creeks and lakes must be designed for ice conditions if the watering systems are to be used year around. In still water, freezing occurs at the air/water surface, and sheet ice forms. In turbulent water, where cold air is mixed in with the water, ice can form at any depth and is called frazil ice. During freezing, water increases in volume by percent and decreases in density by a similar amount, and therefore the resulting ice floats. It is this volume change that often causes damage to intake structures, directly or through soil upheaval.

Water is at its greatest density at 4 degrees C, water at higher or lower temperatures is lighter. This can be used to advantage in systems drawing water from still ponds or lakes. While ice may have formed on the surface, warmer water (4 degrees C vs ice at 0 degrees C) has settled to the bottom of the pond. If this warmer water can be circulated to the surface, ice can be prevented from forming in a small area. The success of this will depend on the air temperatures and the size of this "warm" body of water. Submerged bubbler systems or wind and solar powered lake aeration systems can be used to create this stirring effect.

Freezing Index

The effects from winter temperatures can be estimated by knowing the local Freezing Index. This is calculated from the product of the mean daily air temperature below freezing multiplied by the number of days at that temperature. The sum of all these "degree-days" is the Freezing Index. This index is shown in Table 1, next page for various B.C. locations. It can be used to estimate ice thickness and frost penetration.

Sheet Ice

Sheet ice will form, and keep forming as long as the air temperature is below 0 degrees C. Its maximum thickness is related to the Freezing Index:

Maximum Ice Thickness (in.) = 1.42 $\sqrt{\text{Freezing Index } (^{0}\text{C})}$

For example, in Kamloops with a Freezing Index of 392 (^{o}C) – from Table 1:

Maximum Ice Thickness = $1.42\sqrt{392}$ = 28.1 in.

An intake drawing water from a pond in Kamloops should be deeper than 28 inches to be secure from maximum ice formation during winter.

Table 1 Freezing Index for Various BC Locations (degree-days below °C) [1]

Location	Degree Days C	Location	Degree Days C	Location	Degree Days C
70 Mile House	1071 *	Fauquier	278	Monte Lk Paxton V	673
100 Mile House	834	Fernie	739 *	Mt Robson Ranch	964
Abbotsford A	64	Fort Fraser 135	1043	Nakusp	299 **
Agassiz CDA	68	Fort Nelson A	2457	Nelson	250 *
Alberni	19	Fort St. John	1582	New Denver	275
Alexis Creek	1406 *	Fort St. James	1086	Oliver stp	239
Armstrong	483 *	Golden A	865	Osoyoos west	240
Ashcroft	449 *	Grand Forks	448	Oyama	339 *
Ashcroft Manor	580 *	Grasmere	531 *	Peachland	221
Barkerville	1008	Hat Creek	953 *	Penticton A	239
Barriere	568 **	HazeltonTemlehan	788	Prince George A	920
Bella Coola	162	Hedley	375	Princeton A	566
Big Creek	1139 *	Heffley Creek	688 *	Quesnel A	787
Blue River A	811	Highland V Lornex	690	Revelstoke A	479 **
Bridge Lake 2	783	Hixon	798	Salmon Arm A	416
Burns Lake	1211 *	Horsefly	992 *	Sicamous	373 *
Campbell River	76 *	Joe Rich Creek	642	Smithers A	823
Canal Flats	773 *	Kamloops A	392	Spokin Lake 4E	913
Cecil Lake	1840 *	Kelowna A	363	Topely Landing	966
Chase	405 *	Keremeos	284 *	Tatayoko Lake	710 **
Chetwynd A	1234	Kimberley	861 *	Valemount	956 *
Cranbrook	715	Kleena Kleene	1261 *	Vanderhoof	1227 *
Creston	291	Likely	827 *	Vavenby	601 **
Darfield	515	Lumby	507 *	Vernon	389
Dawson Creek A	1652	Lytton	314	Westwold	563
Dog Creek	909 *	McBride	865 *	Williams Lake	848
Enderby	440 *	McLeese Lake	995 *		
Falkland	455 *	Merritt	474		

1 – data from Environment Canada 1971-2000 unless noted by:

* = data from 1951-1980 - note this older time period usually indicates a colder Freezing Index (by up to 15%)

** = data from 1961-1990 - note this older time period usually indicates a colder Freezing Index (by up to 10%)

A = taken at airport location

CDA = taken at Agriculture and Agri-Food Canada location

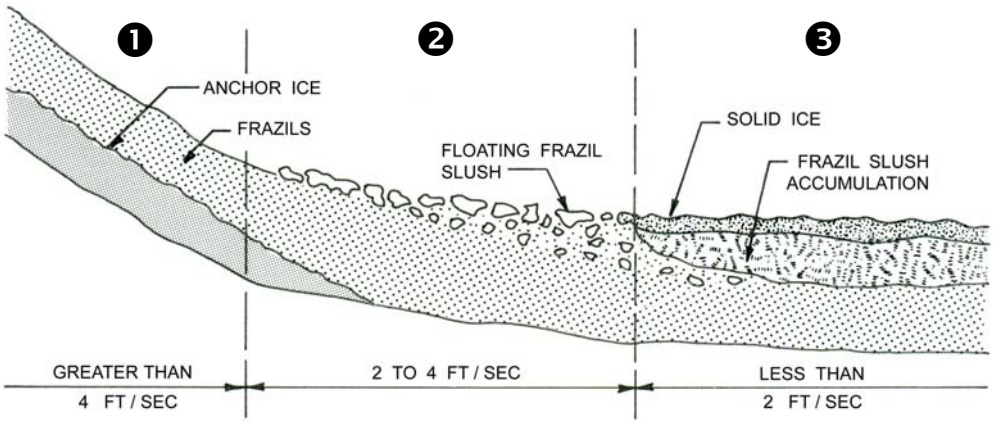
other notations are specific Environment Canada site location identifiers

Wind Chill

Wind removes the thin layer of warm air near a heated object (animal, person, heated trough) increasing its heat loss and is termed wind chill. The object is not cooled below the air temperature; it just loses heat at a faster rate than it would in still air. Once the object reaches the surrounding air temperature it is no longer affected by the wind. Win chill formulas have recently been changed. For current information refer to: http://www.msc-smc.ec.gc.ca/education/windchill/windchill_chart_e.cfm

Frazil Ice

Frazil ice forms in turbulent water and at any depth. It can be difficult to predict and deal with. It may adhere to the stream bed or float downstream where it can contact a water intake or diversion. General recommendations such as reducing the turbulent conditions may not be practical except for in the immediate area of the intake. Ensure vortexing at the intake does not occur. Expert advice should be sought for frazil ice problems as they can be very site specific and beyond the scope of this Factsheet. Figure 1, below, can be used as a guide to the formation of frazil ice.



1. High Velocity	Free water surface, strong cooling, local ice formation. Some is accumulated as anchor ice; most moves downstream.
2. Medium Velocity	Water surface is mostly covered with moving frazil slush, reducing heat loss and ice production. Water temperature is near freezing point. Little anchor ice; tendency for ice to move on.
3. Low Velocity	Solid ice cover reduces heat loss; ice production small. Frazil slush deposited underneath this ice cover and accumulates.

Figure 1 **Formation of Frazil Ice**

Pipelines

All pipelines carrying water year around must be frost protected. The standard protection is earth buried to depths below frost penetration as shown in Table 2, below, for general areas of B C. For more accurate estimates, refer to Frost Penetration, next page.

TABLE 2 ESTIMATES OF PIPE BURIAL DEPTH FOR FROST PROTECTION

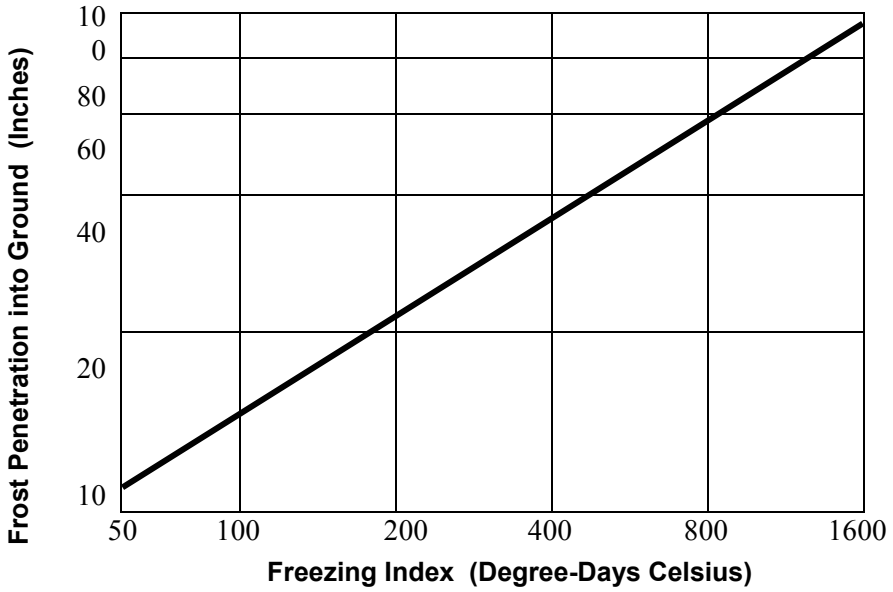
Area	Depth (in)
Vancouver Island	24
Fraser Valley	24
Okagagan Valley *	36
Thompson *	48
Central / Peace River	72

* estimate for valley bottoms – use deeper burial out of valley bottom
for more actuate depth estimates, use local Freezing Index & Table 3, next page

Frost Penetration

Frost penetration can be estimated more accurately knowing the local Freezing Index and using Table 3, below. In addition to these estimations of burial depth, local conditions must be considered. Soil moisture content, soil compaction due to animal or vehicle traffic, surface cover such as grass or snow and micro-climatic conditions should also be taken into account.

Table 3 Frost Penetration versus Freezing Index



adapted from: Canadian Small Hydropower Handbook - B.C. Region

Example – Frost Penetration Estimate

What is the safe pipe burial for a proposed water system in Smithers?

- **determine the Freezing Index for the site**
  - the Freezing Index for Smithers is 823
- **estimate the Frost Penetration for the site**
  - from Table 3, a Freezing Index of 823 equates to frost penetration of 60 inches

A safe pipe burial depth for Smithers is 60 inches. Note that this Freezing Index is taken at the Smithers Airport, and other local areas having significant terrain, etc, differences may have a higher Freezing Index and may require deeper pipe burials.

More Information

For more details on the above subjects refer to

- Climatic data from Environment Canada - Climate Normals and Averages

http://www.climate.weatheroffice.ec.gc.ca/Welcome_e.html

- *Canadian Small Hydropower Handbook – BC Region*

Chapter 9, Winter Considerations
Energy, Mines and Resources Canada, 1989, ISBN 0-662-17178-0

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