SNOW PILLOW EXPERIENCES IN A PRAIRIE (ALBERTA) ENVIRONMENT 1/

611-76

By

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Introduction

The Hydrology Branch of Alberta Environment has been faced for many years with a lack of snow water equivalent data for small watersheds in the province. Alberta spring runoff from the plains is generally produced mostly from snowmelt, which in most cases causes the peak annual flow. Therefore, most of the runoff analyses are dependent upon the preceding winter's snowpack.

With this in mind, the Branch established snow courses in approximately 70 small watershed (less than 1000 square miles in drainage area) throughout the province. All of these courses are in basins of lower elevations, i.e. in the "plains" regions of the province. The majority of these snow courses were established as late as 1969-1970.

In conjunction with this search for more directly related snow data, the Hydrology Branch installed its first 6-foot diameter snow pillow in 1970. Shortly thereafter 4-10 foot diameter pillows were installed and presently Alberta Environment is operating 13 snow pillows at various sites throughout the province.

A careful study of the normal snow depths and water equivalents listed in Table 1, indicates a very shallow snowpack. With the exception of Lee Creek Watershed, the average snow depth is 19 inches and the average water equivalent is 4.0 inches.

Spring Creek Watershed and Lee Creek Watershed have excellent instrumentation and also the longest period of records, which enabled us to test new instrumentation at these sites. The remaining locations are relatively new, i.e. having 1 to 3 years of records but nevertheless producing useful data.

The location and description of these sites are listed in Table 1.

General Purpose

The primary purpose of using snow pillows is to obtain a reliable index of the total accumulated snow water (water equivalent or W. E.) prior to runoff.

A secondary purpose of using snow pillows is that they provide rough estimates of the daily snowmelt loss from the snowpack, which in turn can be utilized for runoff analyses and forecasts.[3] (Also see Figure 2).

General Site Selection

The best site for a snow pillow or snow course is, in general, the best site for a precipitation gauge. The type of site which has been found to yield the most consistent and reliable results is, "an opening in the forest surrounded by hills for protection from high winds, and sloped sufficiently to permit runoff of water beneath the snowpack." (Snow Hydrology, U.S. Corps of Engineers).

However, this ideal type of site is often not available particularly in small prairie watersheds at the so called "lower elevations". Keeping in mind that the selected site should be:

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TABLE 1

STATION NAME	LATITUDE	LONGITUDE	ELEVATION (feet)	PERIOD OF SNOW COURSE	NORMAL DEPTH (inches)	NORMAL WATER EQUIVALENT (inches)	YEARS OF RECORD	PRECIPITATION GAUGES
Fort Chipewyan	58°45'	111°07'	700	Oct.-May	17	3.0	3	Sacramento Storage Gauge 2-6 Foot Snow Pillows Nipher Snow Gauge 10 Point Snow Course
Spring Creek Watershed	54°54'	117°40'	2300	Nov.-April	25.0	6.0	6	5-10 Point Snow Courses 2-Fischer & Porter Recorders 2-Storage Gauges 2-10 Foot Snow Pillows 1-6 Foot Snow Pillow
Paddle River Watershed	53°52'	115°19'	2500	Nov.-April	20	4.0	3	1-6 Foot Snow Pillow 1-Fischer & Porter Recorder 1-Belfort Recorder 1-10 Point Snow Course
Edmonton International Airport	53°19'	113°35'	2630	Nov.-April	15	3.0	2	1-6 Foot Snow Pillow 1-Nipher Snow Gauge 1-5 Point Snow Course 1-10 Point Snow Course 1-Ruler Measurement
Vermilion River Watershed	53°17'	112°04'	2200	Nov.-April	18	3.5	2	1-6 Foot Snow Pillow 1-Belfort Recorder 1-10 Point Snow Course
Pipestone Creek Watershed	53°04'	113°49'	2600	Nov.-April	NO RECORD		1	1-6 Foot Snow Pillow 1-Belfort Recorder 1-10 Point Snow Course
Ghost Ranger Station	51°19'	114°56'	4700	Nov.-April	NO RECORD		1	1-6 Foot Snow Pillow 1-Fischer & Porter Recorder 1-10 Point Snow Course
Lee Creek Watershed	49°03'	113°35'	5000	Dec.-April	40.0	10.0	6	4-10 Foot Snow Pillow 1-Recording Precip. Gauge 2-Storage Gauges 17-10 Point Snow Courses

(1) accessible

(2) representative of the entire basin

(3) free of excessive drifting or melting

(4) permanent.

The selection is a formidable task.[4] There are four major types of sites found in the "plains" regions. They are:

(1) Large Closed Site - This type of site is a clearing (man made or natural) completely encircled by trees with a diameter equal to 4 times the average height of the surrounding trees. This type of site is usually available in heavily wooded watersheds, but snowfall data from this type of site may be affected by "dumping or overcatch" and may not be representative of the entire basin. The "dumping" effect will not occur if the site is in an area of moderate winds during the winter snowfall events. Example: Spring Creek Watershed, Site No. 1.

(2) Small Closed Site - This type of site can easily be found (or made) in watersheds in the plains. The diameter of the opening should be 2 times the average height of the surrounding trees (usually poplars and willows) and should be large enough to prevent drifting into the opening. The leafless trees seem to operate as a wind screen rather than a barrier to the wind. In these sites the snow pillow water equivalents correlate quite well with adjacent open field snow courses, although snowmelt losses are usually higher in the open field. Examples: Vermilion River Watershed - Bruce Site.

(3) Large Protected Clearing - This is the most commonly used type of snow pillow site and can be found in small watersheds in the "plains" regions. Well protected, abandoned farmyards fall into this category and produce excellent data. Careful selection of both snow course and snow pillow locations within the site will reduce under/overcatch of snowfall and also reduce excessive/deficient snowmelt rates. This type of site is usually accessible and the resulting data can be very representative of the entire basin. Examples: Paddle River Watershed - Mayerthorpe Site and Pipestone Creek Watershed - Wetaskiwin Site.

(4) Open Field Site - This type of site is undoubtedly the easiest to find and the hardest to gauge. In a watershed that is 80% to 90% open field it is relatively easy to pick a field which appears to have neither excessive accumulation or excessive depletion of snow. This open area should be either a hay field or pasture, to ensure continuity of record. The 10 point snow course should begin at least 200 feet from the road allowance and extend in a straight line parallel to the prevailing wind for at least 1000 feet. Adherence to proper sampling techniques will eliminate the chance of biased results.[4]

The problem of site selection for a snow pillow in an open field is not as easy as that of the snow course. The snow pillow will measure nothing more or less than that snow which is on it, therefore it is essentially a point sample. Actual site selection should be carried out during the winter prior to installation. This will reduce the possibility that the pillow will be placed in an accumulation or depletion area. The shelter should be installed so that it's presence would not affect snow accumulation on the pillow. Also, special care should be taken to ensure that the top of the pillow is exactly at ground level.

General Operation and Costs

Outlined in Figure 1 is a typical Alberta Environment snow pillow installation, complete with accessory equipment needed to make it operational. To date, all of the snow pillows have been purchased from Watersaver Company, Denver, Colorado, U.S.A. The water level recorders used are A-35 Leupold Stevens models with a 1:1.2 gear ratio. The remaining accessories have been fabricated locally.

Table 2 lists the approximate 1975 cost of the equipment required to set up a snow pillow site. The actual installation time required after a site has been chosen is generally 4 to 5 man-days.

TABLE 2

1975 SNOW PILLOW MATERIAL COSTS:

A) MATERIAL COSTS: (CANADIAN DOLLARS)

1)	Snow pillow	VALUE	VALUE
	(a) 6 foot	315	315
	(b) 8 foot	480	
	(c) 10 foot	588	
	(d) 12 foot	750	
2)	Water level recorder		
	(a) A-35	800	800
	(b) F-type	350	
3)	Stilling well		
	(a) Aluminium	80	80
	(b) Plastic	40	
4)	Shelter		
	(a) Plywood 4'x4'x4'	60	60
5)	Miscellaneous (Hoses, Connectors, staff gauges)	30	30
6)	Methanol (45 gallons) Canada		
	(a) Histological grade	200	
	(b) Certified grade	215	
	(c) Commercial grade	50	50
		TOTAL	$1335

Proper installation will be rewarded with less maintenance and produce better records during the winter months. Careful consideration should be given to the following points:

(1) The top of the pillow must be at ground level.

(2) Insulation of the shelter and of the connecting hose reduces diurnal fluctuations. (Figure 3)

(3) The pillow should be completely filled, thus reducing the chance of a large air pocket forming.

(4) All hose connections must be sealed with tape or glue.

(5) All air must be removed from the pillow and the connecting hose by use of a vacuum pump and by "bleeding" the line.

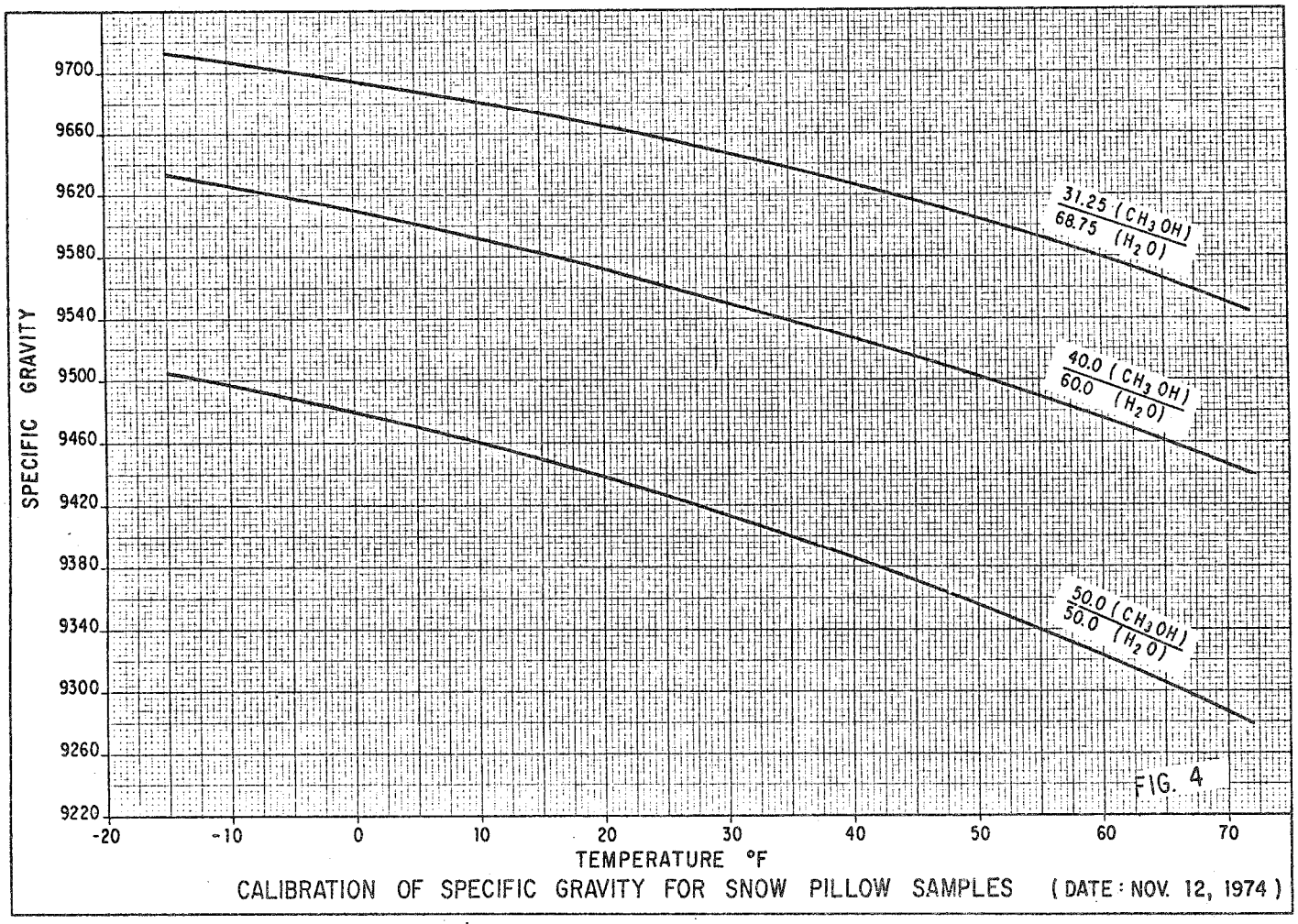
(6) A level check must be taken to ensure that the level of liquid in the stilling well is equal to that of the pillow, when the pillow is bare.

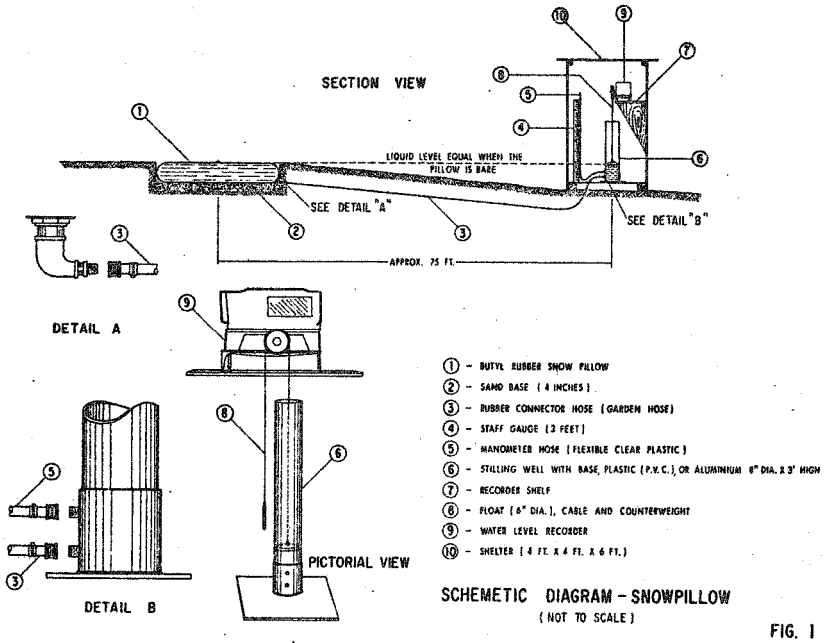
(7) A representative specific gravity sample must be taken from the pillow liquid at the beginning of each winter season. (Figure 4)

(8) A thin layer of oil should be placed in the stilling well to reduce evaporation.

(9) Comparisons should be made with the other precipitation observations near the site.

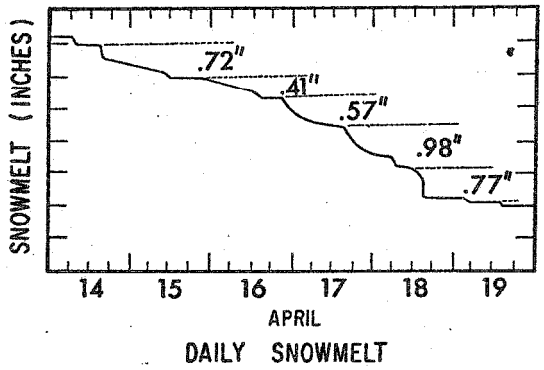
(10) The water level recorder should be serviced to withstand cold temperatures.


SPECIFIC GRAVITY
9700
9660
9620
9580
9540
9500
9460
9420
9380
9340
9300
9260
9220
-20
-10
0
10
20
30
40
50
60
70
TEMPERATURE °F
31.25 (CH3OH)
68.75 (H2O)
40.0 (CH3OH)
60.0 (H2O)
50.0 (CH3OH)
50.0 (H2O)
FIG. 4
CALIBRATION OF SPECIFIC GRAVITY FOR SNOW PILLOW SAMPLES (DATE: NOV. 12, 1974)



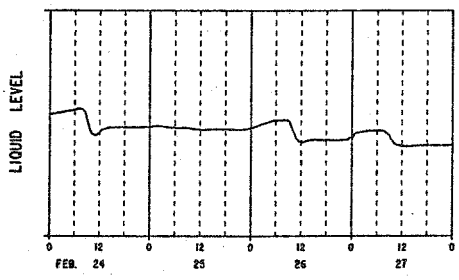
SCHEMETIC DIAGRAM – SNOWPILLOW
(NOT TO SCALE)

FIG. 1



DAILY SNOWMELT

FIG. 2



EXAMPLE OF DIURNAL VARIATION OF LIQUID LEVEL OF SNOW PILLOW DURING MELTING PERIOD (SPRING CREEK No. 2. 1972)

FIG. 3

Data Interpretation

(1) Figure 5: Spring Creek Watershed - Snow Pillow #2

Comparison is shown between the snow pillow water equivalent and

(1) a snow course consisting of 10 sample points spaced at 50 foot intervals

(2) a Fischer & Porter precipitation recorder located at the same site

(3) accumulated Nipher gauge readings for Grande Prairie Airport, approximately 60 miles west of the basin. It is quite evident that the snow pillow and snow course indicates losses of water from the snowpack in late winter whereas the Fischer & Porter gauge cannot show these losses.

(2) Figure 6: Edmonton International Airport

This is a relatively level, open field site, which experiences almost continual drifting, shallow snowpack, crusting and patchwork melting. The snow pillow reacted very well in some cases actually recording drifting snow conditions.

(3) Figure 7: Paddle River Watershed

The lower portion of this watershed is open farmland. The snow pillow and storage gauge are located in a farmyard sheltered by trees. However the 10 point snow course which runs parallel to the pillow, extends into the trees (poplar) which results in higher snow accumulation and consequently higher water equivalent values.

(4) Figure 8: Lee Creek Watershed

The main purpose of snow pillow site No. 26 is to measure interception losses by the forest canopy.

These 2-10 foot snow pillows are situated approximately 50 feet apart, one in a clearing of spruce trees and the other under the trees.

This site experiences frequent chinooks throughout the winter and as shown in Figure 8, each pillow reacts differently.

Conclusions

(1) Snow pillows can definitely be used to measure shallow snowpack water equivalents under prairie conditions.

(2) Snow pillow water equivalents should be considered as point samples only, which may or may not be representative of the entire watershed. The accuracy of the data depends heavily on proper installation of the devices and their representativeness depends upon the general location of the site as well as upon the specific location of the pillow within the site.

(3) Large, well protected clearings, as can be found in abandoned farmyards are excellent locations for snow pillow and other precipitation gauging equipment.

(4) Snow pillows successfully meet the two basic requirements:

(a) they record the cumulative water equivalent in the snowpack, taking into account evaporation and sublimation losses, thus providing a net total index of water equivalent available in the snowpack prior to spring runoff.

(b) they provide rough estimates of daily snowmelt losses from the snowpack, which in turn can be utilized for runoff analyses and forecasts.

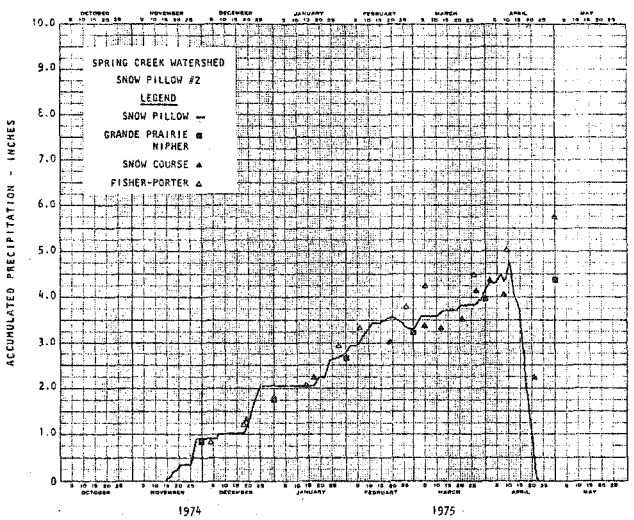


FIG. 5

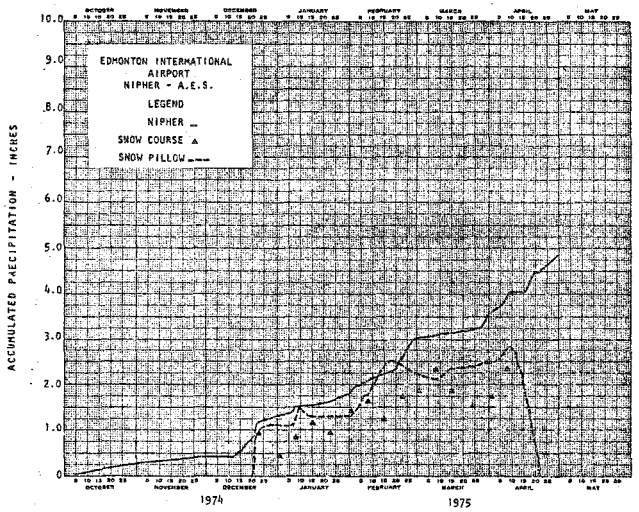


FIG. 6

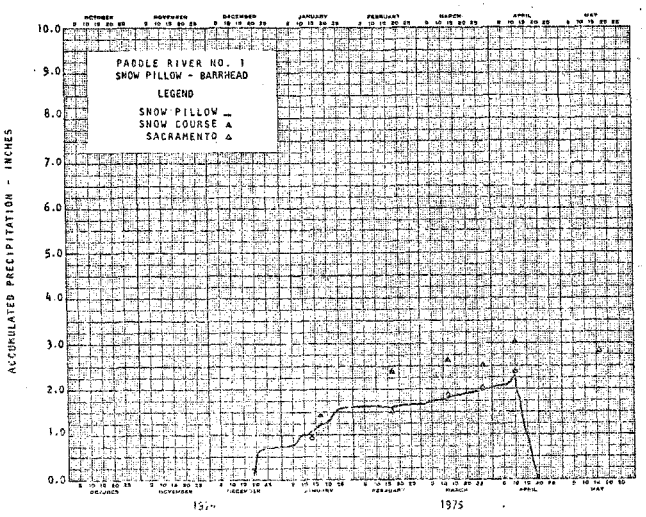


FIG. 7

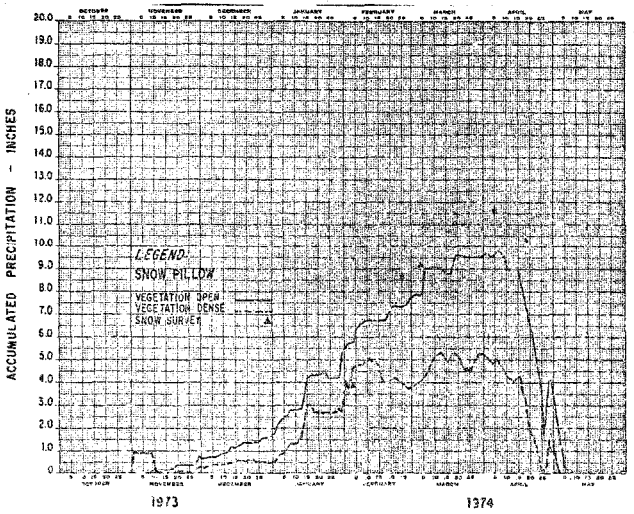


FIG. - LEE CREEK WATERSHED (SNOW PILLOW № 26)

FIG. 8

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