# SNOW PILLOW OVERLOADING BY SLOPE INDUCED CREEP

766-84

by
Robert P. Richards(1)

## INTRODUCTION

The Water Management Branch of B.C. Environment in cooperation with B.C. Hydro operates a snow pillow at Morrissey Ridge, about 13 km south and east of Fernie, B.C. The pillow was located near the Morrissey Ridge snow course (#2C09), a Columbia River Treaty station used for water management in the Kootenay River Basin. Although the snow course has been measured since 1961, a snow pillow was not installed until 1974. It was one of four demonstration H.A.T.S. (Hydrometeorological Automated Telemetering Station) sites established in the Columbia Basin. It was designed to transmit, on command, hydrometeorological data to Vancouver, B.C., via VHF telemetry using B.C. Hydro's land based microwave repeater network. The 1.2 meter pillow was too small for the snowpack conditions, and little reliable data was actually collected with it and a 3 meter replacement was installed in 1979. This paper summarizes the investigation completed to isolate the problem of creep loading of the new pillow observed after the first season, define its magnitude and recommend a solution.

## PILLOW OPERATING PROBLEMS

Snow pillows are subject to many problems which were reviewed by Cox, et al (1978), including load variation resulting from creep. Creep is the downslope deformation or translation of a snow mass by gravity, and creates additional load on any surface which projects into its path.

The Water Management Branch snow survey Operations Unit installed the 3 meter pillow in 1979 at the same location as the original. In the first season it was evident that creep or some other factor was affecting the results. The data was corrected for the overmeasure by pillow periphery core sampling while investigations into possible causes continued. Specific analysis of the overloading was deferred until the 1982/83 season, when conversion of the VHF to satellite DCP was scheduled.

The practice of the snow survey unit on site selection calls for a well drained area with a maximum ground slope of 10% (Procedure Manual, 1982). This slope limitation, while somewhat arbitrary, was also considered to be the creep threshold by Cox, et al (1978). The ground slope was a consideration in this installation, but more in terms of creating a large enough site to level a 3 meter pillow than in concern over creep. Furthermore, the instruments and equipment which would have to be moved was owned by two different agencies.

## INVESTIGATION

The investigation of Morrissey Ridge included a literature search, preparation of site topography, core sampling on and around the pillow, snowpack profiling and trenching to isolate the pillow from the uphill snow mass. In unpublished notes, Weiss (1983) reviewed the various possibilities including slope effects, ice bridging, brush and vegetation conditions and uneven snow accumulation (drifting). In an examination of site photographs he estimated the ground slope at 20% (rather than the 10 to 15% originally assumed), based on ground/tree relationships. It was twice the arbitrary limit adopted by the snow survey unit.

Ground truth was obtained with the Standard Federal cutter corrected for overmeasure at the ratio of 0.9095 of the measured value as determined by the Western

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(1)Head of Snow Survey Operations, Water Management Branch, British Columbia, Ministry of Environment, Victoria

Snow Conference Cutter Testing Program (Farnes, et al, 1983). Snow pillow periphery samples were taken monthly during operations from which the percent overload was computed. The correction to compensate for pillow fluid density (S.G. ≃ 0.97) was not applied.

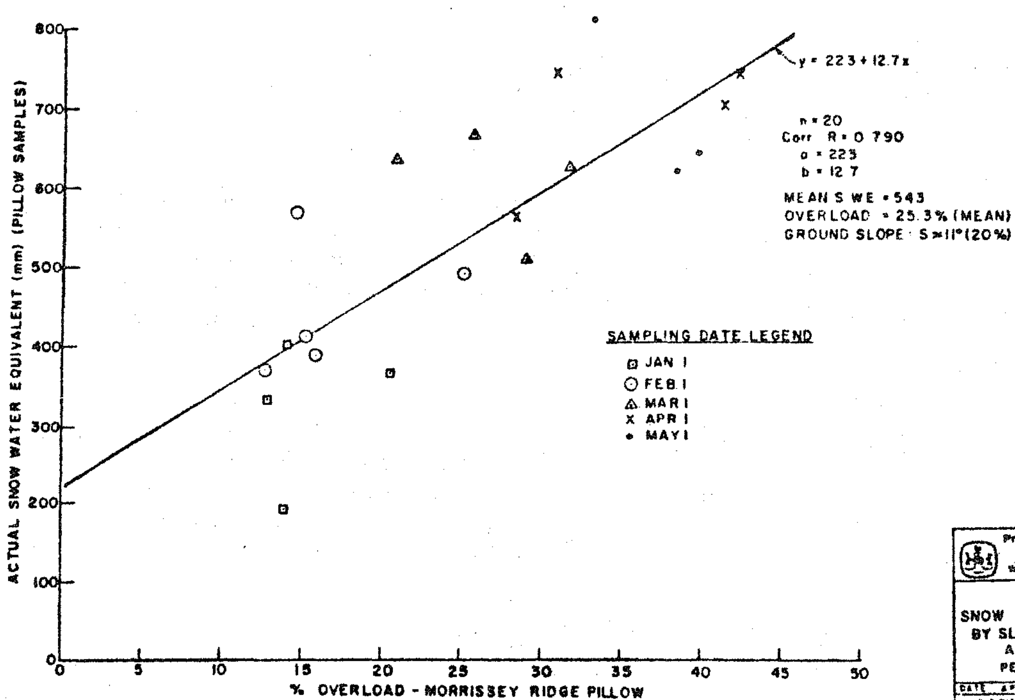
Field testing at the pillow site included a detailed coring pattern on and near the pillow (the pillow was covered with sheet steel), cut-off trenching on the uphill side of the pillow and snow profiling. The pillow recorder was geared to feed chart paper at the rate of 3 cm per hour in order to identify detailed load changes.

Analytical methods to determine creep loads have been developed for wide solid barriers set normal to the creep surface (McClung, 1982). No attempt was made to apply such an analysis to the Morrissey Ridge Pillow.

## STUDY RESULTS

### (a) Periphery Coring

The program of periphery coring has long been associated with snow pillow calibration. The corrected values were used to compute the percent overloads plotted in the following graph (Figure 1) against actual SWE:

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P. F. RICHARDS, ENGINEER
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FIGURE I

There is some correlation indicated between SWE and overload although with a great amount of scatter. The apparent zero overload at approximately 200 mm of snow water equivalent cannot be confirmed.

### (b) Ground Truth Testing

Ground truth was established by extensive core sampling on and near the pillow prior to cut-off trenching. The corrected value of the SWE was 770 mm. The indicated pillow loading dropped by 28.4% from 1075 to 770 mm following the trenching.

### (c) Snow Profile

The snow profile indicated a ripening snowpack with free water present at several density interfaces and at the ground surface. Free water contributes directly to creep (McClung, 1982). There were no ice lenses present at the time of the test.

(d) Cut-off Trenching

Two trenches were excavated upslope from the pillow (see Figure 2), the first just off the fall line had little effect compared to the second one across the fall line. The difference, illustrated in Figure 3, is substantial indicating the strong downslope load component acting on the pillow. Immediately following the release of the overload, recovery occurs, likely the result of not completely isolating the pillow from the surrounding snowpack. The mechanics of this process is beyond the scope of this investigation. The pillow load trace for the test season (1982-83, shown in Figure 4) clearly shows the elimination of the overload following the field tests.

## CONCLUSIONS

The net load change over the 24 hour period, exclusive of melt, was a reduction of 170 mm, all attributable to creep. The amount of overload was proportional to the true snow water equivalent as illustrated in Figure 1.

The overload of 39.6% prior to the test, based on the ground truth of 770 mm SWE, was virtually eliminated by the upslope cut-off trench.

Relocation of the pillow in September 1983 to a less inclined site was approved on the basis of the test results and has now been operating successfully for two thirds of the 1983/84 season.

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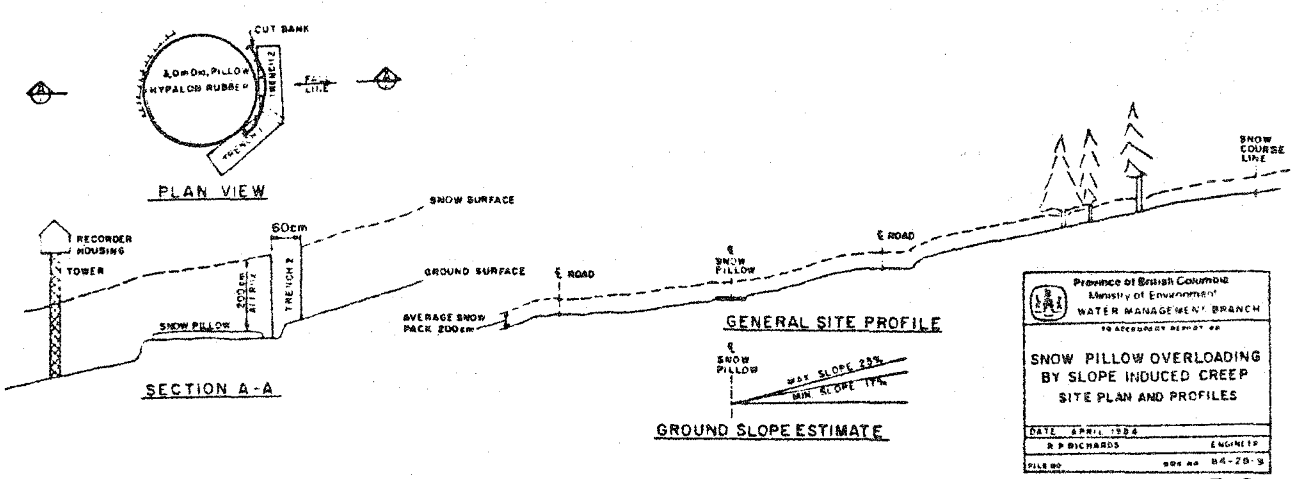


FIGURE 2

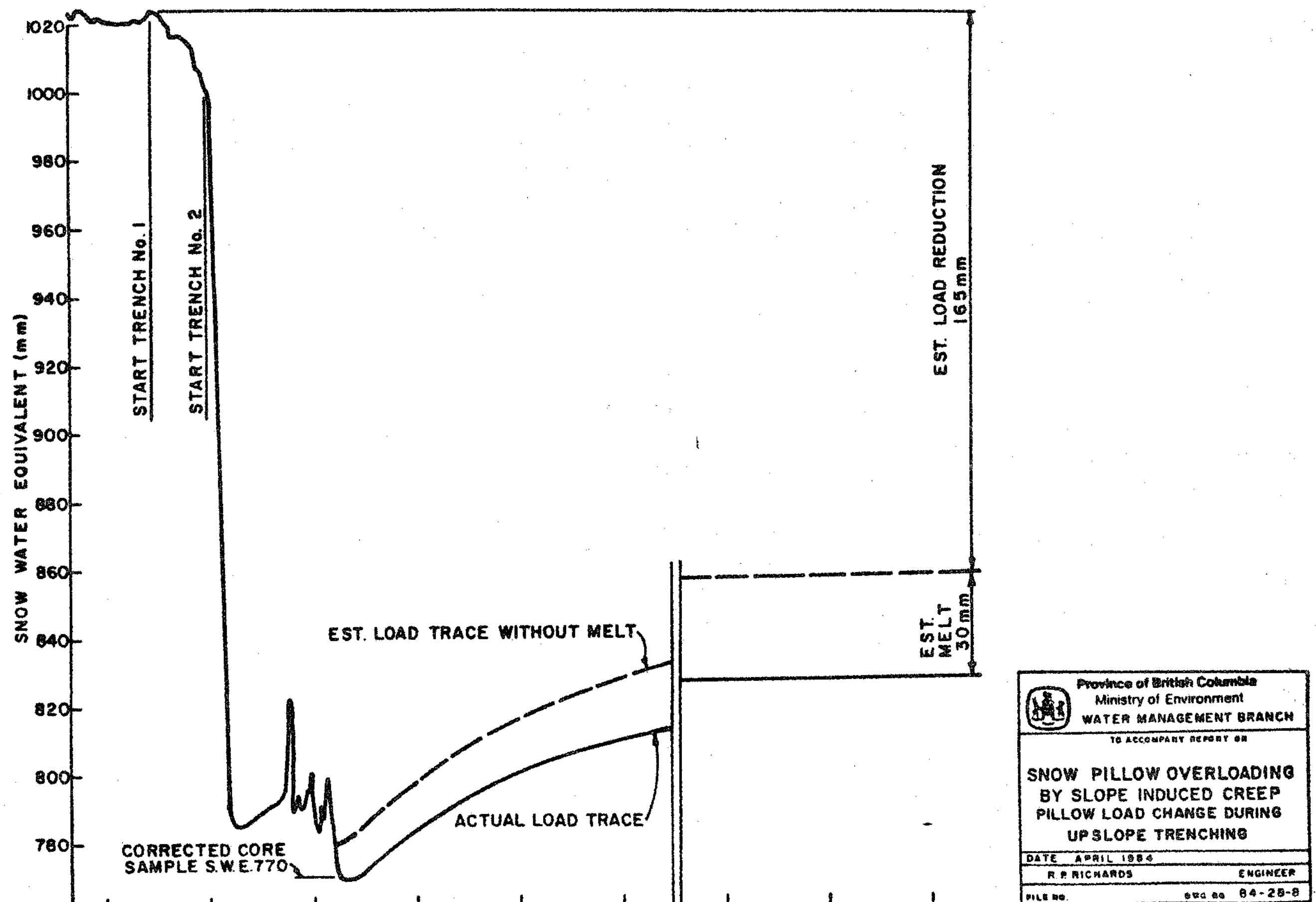


FIGURE 3

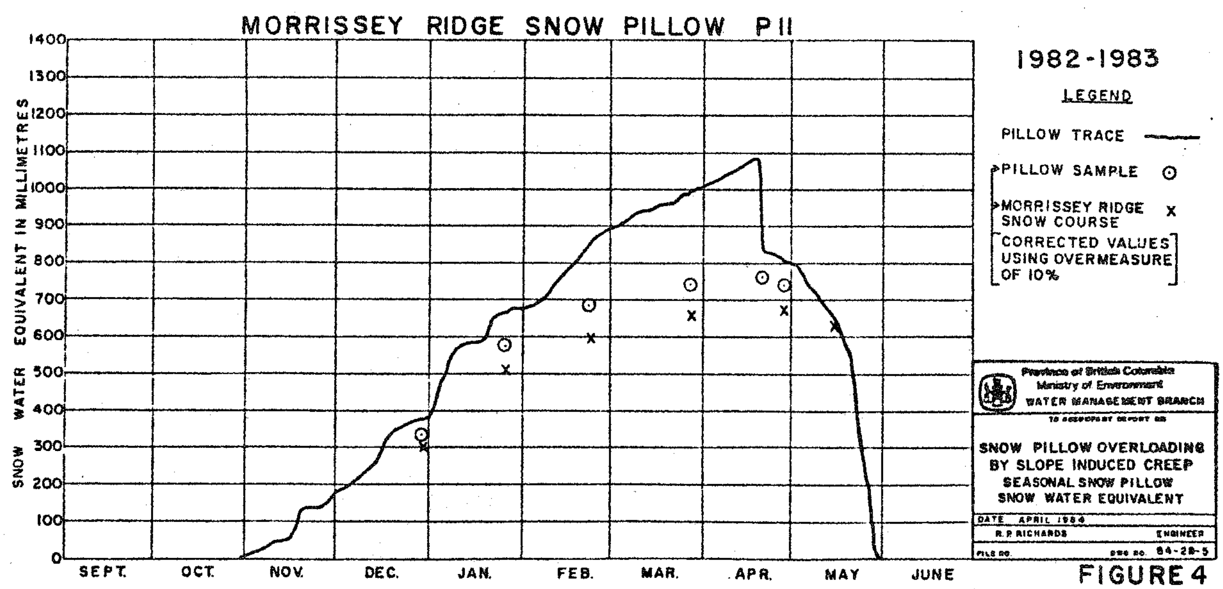


FIGURE 4