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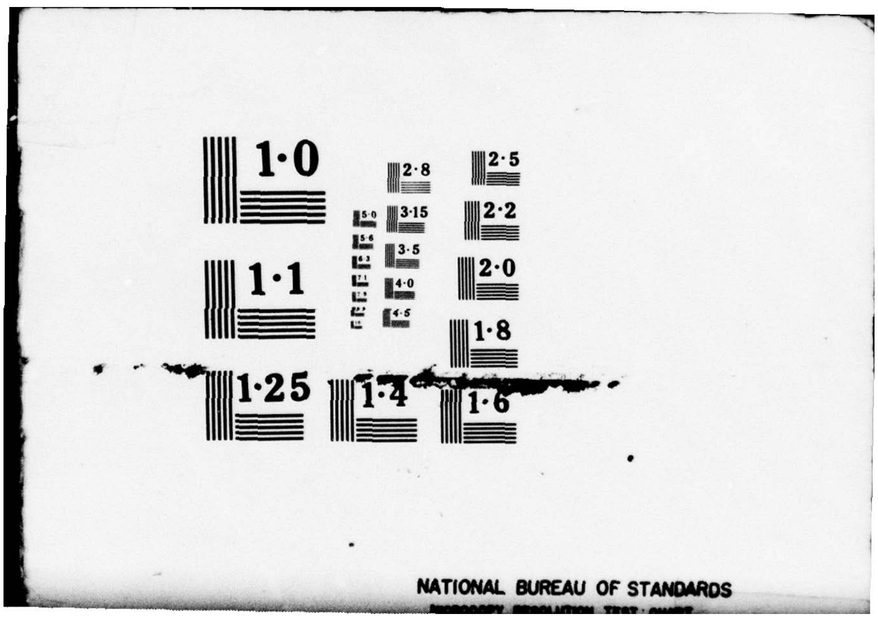
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FRESH WATER SUPPLY FOR A VILLAGE SURROUNDED BY SALT WATER

POINT HOPE, ALASKA

Terry McFadden and Charles Collins

April 1978

CORPS OF ENGINEERS, U.S. ARMY
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Point Hope is a village located on a narrow gravel spit extending eight miles out into the ~~Bering~~ CHUKCHE Sea. Studies to locate an adequate fresh water source for the village have yielded two possible supplies which will fill the needs of the village. The first is a ground water supply existing on top of the undulating permafrost layer which underlies the gravel spit. This supply consists of several million gallons of water and can be augmented with snow fences which will drift blowing snow into areas where it will drain into the

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aquifer when it melts. Excess water will overflow the sides of the natural permafrost basin into the ocean on both sides of the spit. The second source is a small lake located approximately four miles from the village. The lake provides water of adequate quality and quantity to be used as a raw water supply; however, this source is not as desirable since it is surface water and supports a higher level of bacterial contamination. In addition, it is a much greater distance from the village and longer and much more expensive piping would be required to get the water to the village.

PREFACE

This report was prepared by Dr. Terry T. McFadden, Supervisory Mechanical Engineer, and Charles M. Collins, Research Physical Scientist, of the Alaskan Projects Office, U.S. Army Cold Regions Research and Engineering Laboratory.

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INTRODUCTION

The village of Point Hope, like many coastal villages in Alaska, suffers from a lack of drinking water during the winter. Presently during the winter water is obtained by melting snow dug from drifts near the homes. This gives a small return for the energy input and is a very unsanitary practice because of loose dogs roaming around the village. A second source of water comes from melting ice cut and hauled from a lake about four miles to the east. Storage of this ice near the homes results in the same sanitary problems encountered with the use of snow. Because of the difficulty involved in getting water, its use is restricted to a point that falls below that required for good sanitation and health practices. Since the village site is on a narrow gravel spit less than a mile wide which juts out into the ocean nearly eight miles, a fresh water source that could be relied upon for a village supply was considered unlikely, and probably not economically feasible. However, in the summer, water is readily available from very shallow wells dug in the gravel of the spit. It was speculated that this fresh water was an aquifer perched on the surrounding salt water which probably circulated under the spit, and that any attempt at a major withdrawal of water would upset the equilibrium and cause salt water intrusion.

In March of 1976 the Alaska Native Health Office of the U.S. Public Health Service asked CRREL to evaluate possible water sources available for a village water supply and determine if any would be suitable for summer filling of a storage tank located in the center of the village. The tank could then be used all year round as a village water supply.

TOPOGRAPHY

Point Hope lies along the northwest coast of Alaska, approximately 130 miles (210 km) north of the Arctic Circle (Fig. 1). The Point Hope peninsula resembles a triangular breakwater and consists of two bars or spits converging approximately 15 miles (24 km) west of the mainland (Fig. 2). They enclose a large, shallow body of salt water known as Marryat Inlet. The mouth of the Kukpuk River empties into this inlet with the inlet opening to the sea through a narrow pass in the northern leg of the triangle.

The gravel bar or spit forming the southern side of the triangle extends to the southeast to a low series of cliffs on Cape Thompson and contains a string of shallow fresh water lakes.

The peninsula consists of alluvial plains in the northern and eastern section made of stratified silts and sand with peat and tundra vegetation. The younger southern and western sections are made up of marine beach deposits consisting of well sorted gravels and sands (Larson and Rainey 1948).

Figure 1. Point Hope geographic location in Alaska.

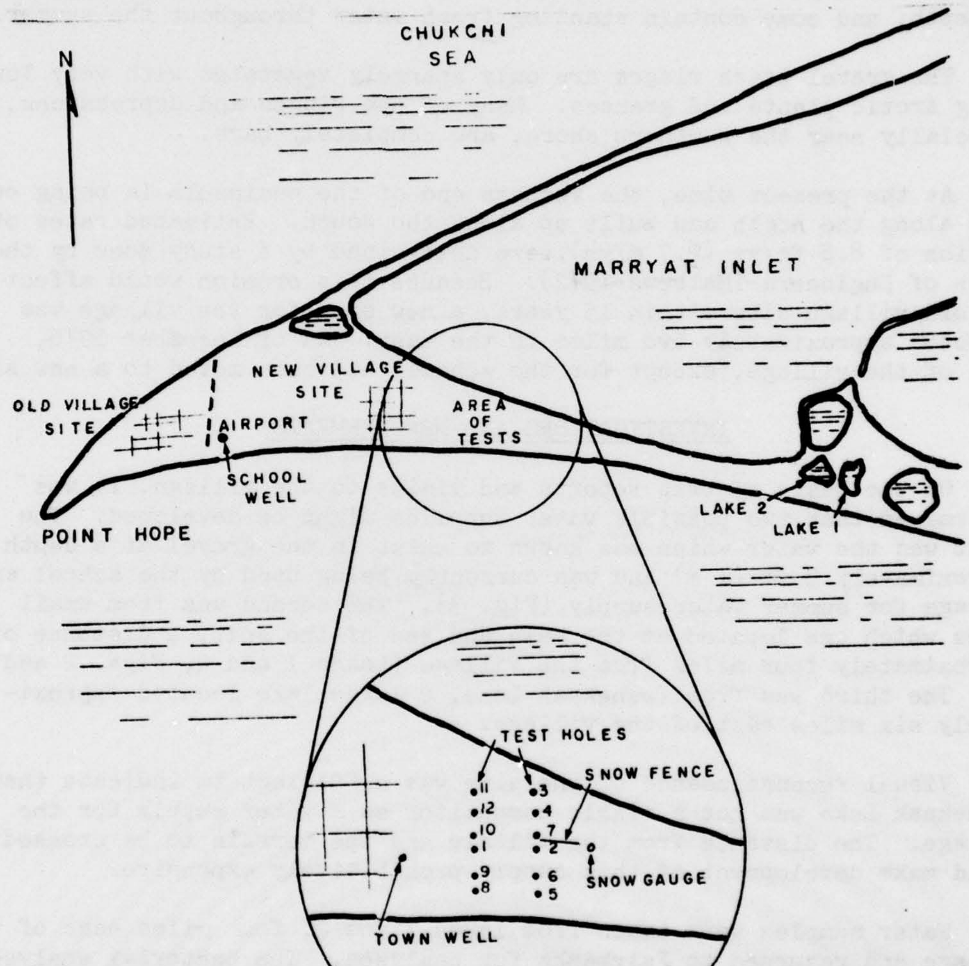

Figure 2. Point Hope vicinity.

The triangular western end of the peninsula, site of the village of Point Hope, consists of a series of regular canal-like depressions separating parallel ridges. It is speculated (Larsen and Rainey 1948) that these marine beach ridges are formed by pressure ridges in the pack ice when the ice is driven into the shore by wind and current. The channels or depressions between the ridges vary from 2 to 6 ft (0.6 to 2 m) in depth; and some contain standing fresh water throughout the summer.

The gravel beach ridges are only sparsely vegetated with very low lying arctic plants and grasses. Many of the ridges and depressions, especially near the southern shore, are completely bare.

At the present time, the western end of the peninsula is being cut away along the north and built up along the south. Estimated rates of erosion of 8.8 ft/yr (2.7 m/yr) were determined by a study done by the Corps of Engineers (Mathews 1972). Because this erosion would affect the old village site within 15 years, a new site for the village was selected approximately two miles to the east. As of December 1976, most of the village, except for the school, had been moved to a new site.

INVESTIGATIONS AND MEASUREMENTS

On the basis of trip reports and visits to the village, it was determined that two possible water supplies might be developed. The first was the water which was known to exist in the gravel at a depth of approximately 3 ft (1 m) and was currently being used by the school and village for summer water supply (Fig. 3). The second was from small lakes which are located at the mainland end of the spit, a distance of approximately four miles from the village (Lakes 1 and 2, Figs. 2 and 4). The third was from Teshekpak Lake, a large lake located approximately six miles east of the village.

Visual reconnaissance of the site was sufficient to indicate that Teshekpak Lake was not a viable competitor as a water supply for the village. The distance from the village and the terrain to be crossed would make development of this supply prohibitively expensive.

Water samples were taken from lakes 1 and 2, four miles east of the village and returned to Fairbanks for analyses. The bacterial analyses are given in Table I. As can be seen, the coliform counts in these potential surface water sources were higher than those allowed for an untreated water supply; however, in lake 2, the count was well within raw water standards and would be adequate for a treated supply. The water in the lake was clear, and the quantity was sufficient to supply the needs of the village.

Figure 3. Surface water well in the gravel of the spit. Note well is enclosed to protect well from contamination.

Figure 4. Small lakes at the east end of the spit.

Table I. Bacterial Analyses of Selected Water Sources at Point Hope.

Well Location/no.	Total coliform (No./100 ml)	Fecal coliform (No./100 ml)
Town well	34,000	22
School well	3,000	0
Lake no. 1	5,200	4
Lake no. 2	140	1
Amos' well	120	0

Table II. Chemical Analyses of Selected Water Sources at Point Hope.

Well Location/no.	Total hardness (mg/l)	Total alkalinity (mg/l)	Calcium (mg/l)	Chloride (mg/l)	Iron (mg/l)	Nitrate (mg/l)
Lake no. 2	48.7	10.9	8.0	85.3	0.42	0.65
Town well	110.0	74.1	74.1	40.0	--	--
School well	136.0	125.0	38.0	33.9	0.06	0.80
Well no. 1	243.0	101.0	28.0	33.9	0.12	3.50
Well no. 5	85.7	56.4	15.9	118.0	--	--
Well no. 6	91.1	85.4	24.0	47.1	0.08	0.20
Well no. 7	106.0	70.2	21.0	73.0	--	--
Well no. 8	103.0	56.7	20.8	82.0	--	--
Well no. 10	128.0	67.8	26.5	58.0	--	--

At the same time, samples were taken of various shallow wells approximately 2 to 3 ft (0.6 m to 1 m) deep with 12 in. to 16 in. (.30 m to 0.41 m) of water. The results of these tests are also given in Table I. No fecal coliform counts were present in either the school well or Amos' well; however, total coliform counts were still too high for direct use without treatment. The town well was found to be badly contaminated.

An assessment of the amount of water available in the gravel aquifer of the spit was then attempted. This was approached using a sampling technique. Twelve shallow wells were dug. During the digging, it was discovered that the spit is underlain with fresh water permafrost at a depth of approximately 3 ft (1 m). Contrary to previous speculation, salt water does not underlie the gravel, at least at shallow depths, and the fresh water ice provides an impermeable base to the spit. During the summer season, the active layer extends to a depth of 3 to 5 ft (1 m to 1.5 m) below the surface.

The spit is composed of long gravel ridges which run parallel to the ocean (Fig. 5). Between these ridges are small channel-like depressions. The active layer in the spit is approximately the same thickness throughout the gravel areas of the spit. Thus, the surface of the permafrost table is parallel to the gravel surface, and is also composed of a series of ridges with small valleys or channels between them. These channels fill with water when the snow accumulated on the spit each winter melts during the summer.

In order to make a reasonable estimate of the quantity of water contained in these long channels, a 2000-ft (610-m) section of the spit located approximately one-half mile to the east of the village was chosen as the most likely area from which to draw water for the new village. The estimate was made as follows - elevations of the surface of the spit were taken along two lines 1000 ft (305 m) apart across the width of the spit (Fig. 3). Based on these two cross sections and the depth of the water as found in 12 test wells shown on the cross sections, an estimate of the total water available during the period of maximum thaw was made. Assuming that the average area of the channel is represented by the cross section for a distance of 500 ft (152.4 m) on each side of the cross section and that the channels are continuous (or could at least be interconnected), then the volume of a 2000-ft (610-m) section of the channel can be estimated. From this it appears that at least 12.1×10^6 gal (3.41×10^5 m^3) of water are available in a 2000-ft (610-m) length of the largest of the depressions, and a maximum possible volume of 15.1×10^6 gal (4.3×10^5 m^3) could be stored in it before it overflowed to the ocean.

Figure 5. View of Pt. Hope spit showing gravel ridges.

An approximation of the volume of water in this 2000-ft (610-m) section across the total width of the spit can also be made using the cross sections. This suggests that 20.7 x 10^6 gal (5.9 x 10^5 m^3) are contained in this section of the spit. If this sample is typical of the entire spit (since this is one of the narrowest sections of the spit, this is a very conservative estimate), then we can assume that at least 328 x 10^6 gal (9.3 x 10^6 m^3) of fresh water lie in the gravel of six-miles of the spit during the period of maximum thaw. (August, September)

To further confirm these measurements, pumping tests were run on two wells. On 27-28 August 1976, each well was pumped at the rate of 100 gal (0.4 m^3)/min for 9 hours, giving a total of 54,000 gal (200 m^3) pumped to the ocean from each well. During the pumping, there was a drawdown of the water level in the test wells varying from 4 to 12 in. (10 to 30 cm). However, almost immediately after pumping ceased, the water level in the wells returned to the original level. No permanent lowering of the water level of the well could be measured, indicating that the total volume of the water available from this channel is very large and lending credence to the previous measurements based on the geometry of the channels.

AQUIFER ENHANCEMENT

The parallel channels are probably not interconnected. Not only do the water analyses show differing amounts of some chemicals in adjacent channels, but water levels are different in parallel channels (see Table II and App. A). It should, however, be a relatively easy task to form cross canals to connect two or more of the channels to increase the available supply to a collection gallery. Likewise, a reservoir within the gravel could be created simply by leveling or dishing out the gravel in the center and leaving a gravel berm around the perimeter of the desired areas. This allows the permafrost to melt into a basin beneath the surface to provide a gravel-filtered reservoir in which to store snow melt water and melted permafrost. Permafrost would rise under the berm to seal off the sides.

The reservoir should not be more than 2 ft deep in order to keep the gravel surface above the level of the water. This provides a cover to the reservoir, keeps out trash and animal contaminants, and helps to maintain higher water quality.

If more water is needed, the reservoir could be enlarged simply by scooping out a larger area. This could easily be accomplished with a crawler tractor in a few hours. Such equipment is currently available at Point Hope. If still more water is needed, it could be obtained by removing gravel to the top of the permafrost. This sacrifices the advantage of the gravel cover over the top since the water surface would be above the gravel; however, it is a relatively inexpensive means of obtaining larger reservoir capacity.

SNOW ENHANCEMENT

A preliminary investigation of the snow quantity in the vicinity of the village was done in May of 1976 to determine if snow melt water could be used to supplement the water supply. It indicated that adequate snow did exist in the area. This could be concentrated in a desired location with the use of snow fencing since blowing snow is common throughout this portion of Alaska. Since no adequate snowfall records were available for this area, a "Wyoming-type" snow gauge was erected at the site to give snowfall records for the winter of 1976-1977 (Fig. 6).

The "Wyoming" snow gauge was designed to measure snowfall in windy areas where blowing snow is a problem, and the results obtained from it gave a relatively accurate measurement of the snow available at this location. The total accumulation from 3 November 1976 to 20 April 1977, as measured by the gauge, was 1.39 in. (3.53 cm) of water equivalent.

In addition to the snow gauge, 666 ft (203 m) of snow fence were erected to measure the effectiveness of using a fence to accumulate snow. The snow fence was installed along the spit in an east-west direction, perpendicular to the storm winds (Figs. 7 and 8). Measurements of the depth and density of the snow drift accumulated through the winter were made in late April 1977.

Figure B1 (App. B) is a plan view showing the location of four cross sections taken through the fence and associated snow drift. Figures B2a-d show the four cross sections. Each of the last four sections shows the cross sectional area of the drift and representative snow densities. The four cross sections give an average cross-sectional area of the drift of 326 ft (30.3 m) with an average density of 0.34 g/m^3. This indicates that, on the average, each meter of snow fence collected 2720 gal (10.3 m) of water. The total length of the fence collected 552,160 gal (2091 m^3) of water.

The winter of 1976-77 was a comparatively low snow year, according to reports of the villagers and also as shown by the small amount of precipitation (3.53 cm) caught by the snow gauge. Despite this, the snow fence was able to collect a large drift simply due to the large source area available to the north and south of the fence, and the continual winds that exist in the area.

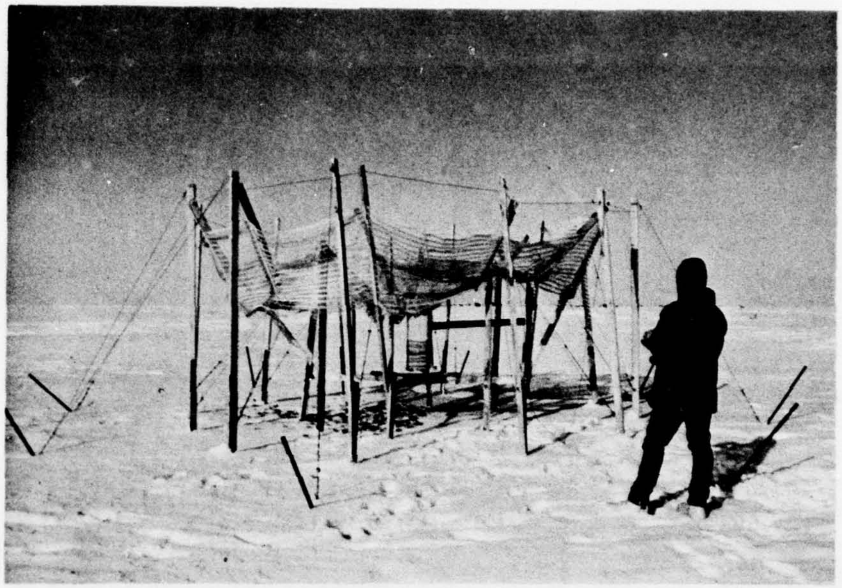

Figure 6. Wyoming snow gauge.

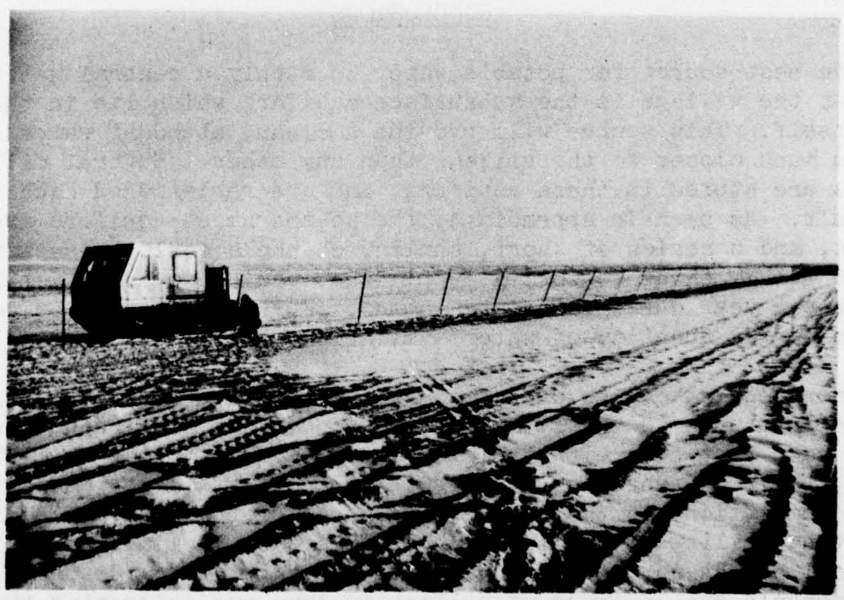

Figure 7. Installed snow fence.

Figure 8. Snow fence and associated drift.

CONCLUSIONS

The best source for potable water to supply a central watering point at the village is the subsurface aquifers which lie in the gravel spit itself. This source will provide a clean, abundant water supply that is much closer to the village than any other. Several million gallons are stored in these aquifers, and are replenished each year from snow melt. As seen in Appendix A, the southernmost aquifers are the largest, and a series of short, shallow channels could connect the largest two or three to form a supply that could provide several million gallons per year during the late summer. Further refinements could make an even larger quantity of water available.

Snow fencing can be used to increase the water supply. This would provide insurance in the event of a low snow year or drought conditions. It was seen that even with the extremely low snowfall of the 1976-1977 winter, the snow fence was capable of collecting a drift much larger than accumulations on the surrounding areas of the spit. In fact, the collecting ability of the snow fence appears to be limited only by the practical height to which it can be built. A properly designed fence could serve a dual purpose of collecting snow and protecting the enclosed water collection area from animal contamination.

Contamination of the aquifer by salt is probably not a problem since the chloride levels in the sample taken from this source were very low. The possibility of salt contamination does exist from storm tides, but since the prevailing storm winds are from the north, Marryat Inlet provides an effective shield from salt intrusion from this direction (Fig. 2). Identification of this potential source of water and the ease with which it can be enhanced leads to some encouraging speculation for water supply in coastal areas that were heretofore considered impossible.

The lakes in the area could provide an acceptable supply of water, but are a second choice because of the much longer distance that the water must be transported, and because of fecal contamination from water birds which frequent them.

RECOMMENDATIONS

A section of the spit 1000 ft by 1000 ft should be levelled and dished to the center to a depth of 18 in. (0.5 m) to provide a water collection area. If the center of the area is not deeper than 20 in. below the sides, no water should appear on the surface. This gives a gravel cover to the reservoir and doesn't attract water birds or other animals that would contaminate it.

Fencing should be used to protect it from animal contamination. The fence should be covered with plastic snow collecting mesh to enhance the drifting within this area. The fence should be approximately 4 ft in height. A collection gallery should be buried in the gravel at the top of the permafrost to gather water for pumping to a central storage tank.

The area chosen should start at least 2000 ft east of the village and at about 400 ft north of the south shore of the spit. This area is clean gravel and is essentially free of soil. It should store approximately 8×10^6 gal of water after the first winter's snow melt fills the depression.

Pump capacity should be designed to be capable of filling the storage tank during the month of August since this will be the time when the maximum water is available in the gravel covered reservoir.

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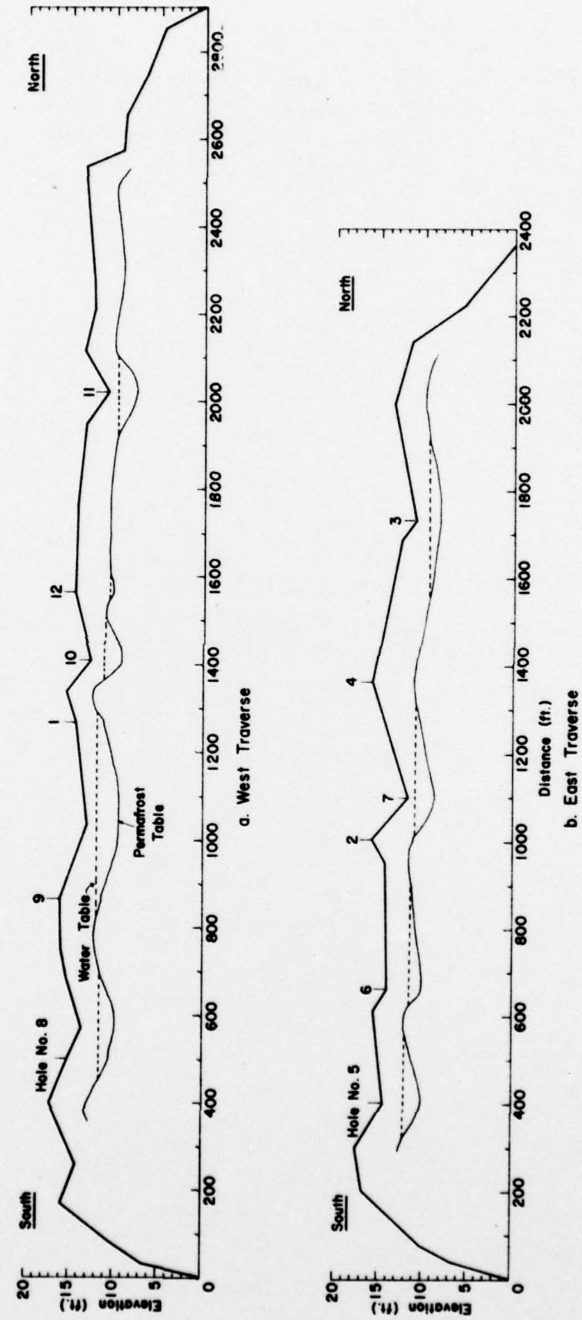
Appendix A

Survey Cross Sections



Appendix B

Snow Fence Cross Sections

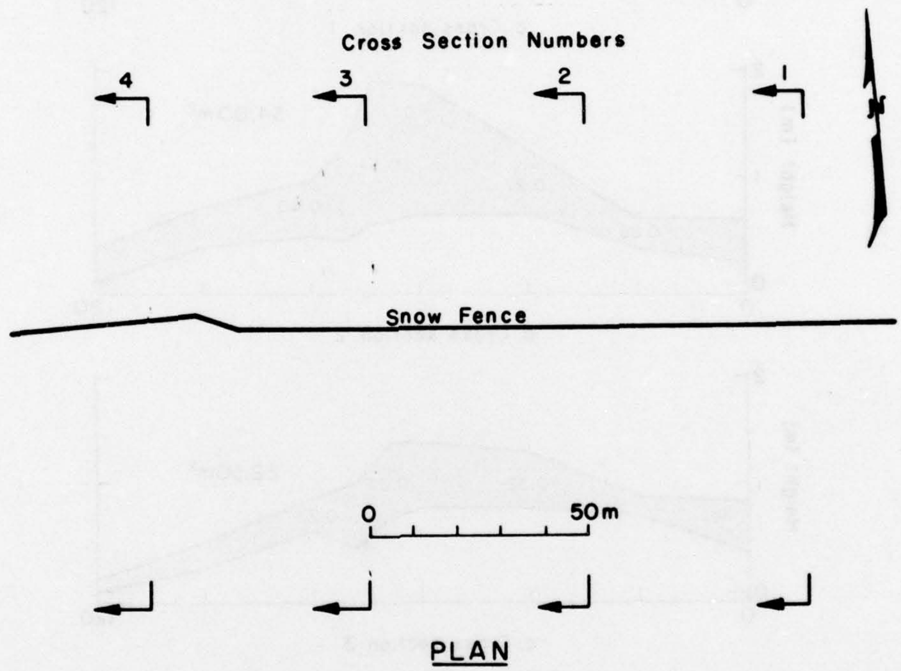


Figure B1. Plan view of four cross sections.

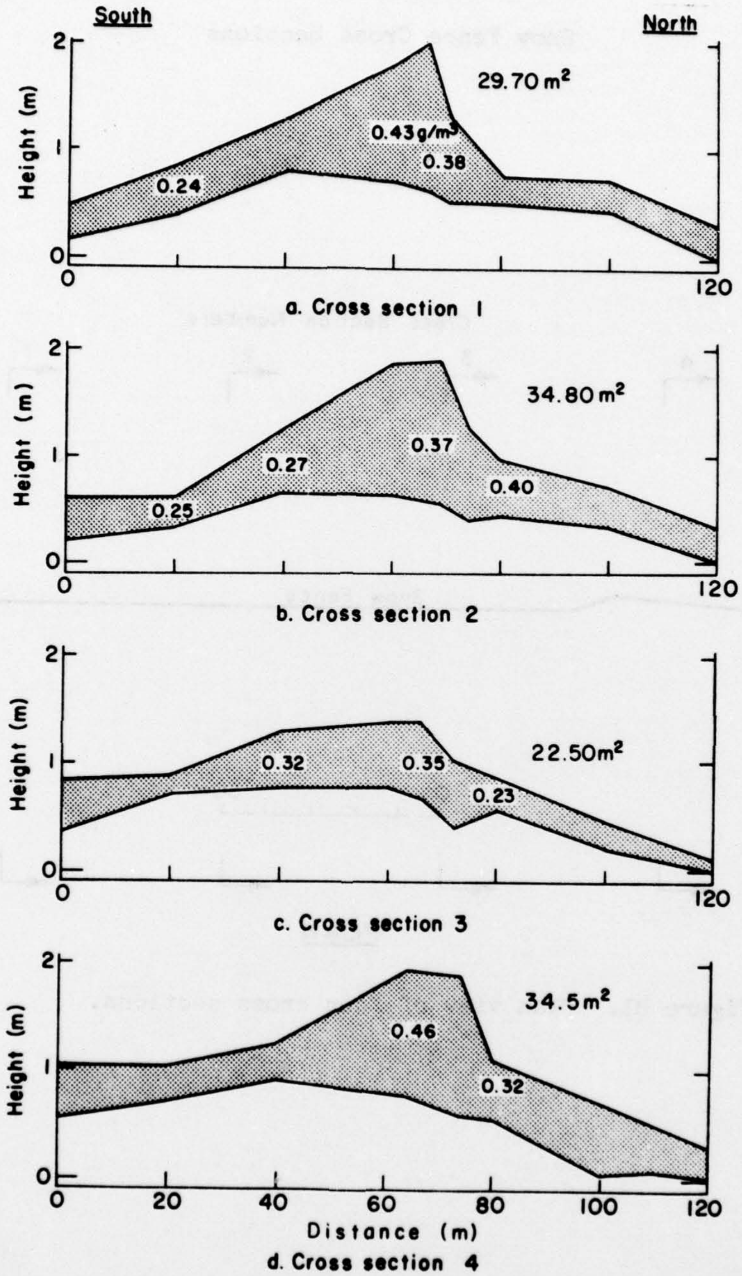


Figure B2. Four cross sections with snow densities.