Special Report 240

CONTROL OF SNOW AND ICE ON MISSILE FIELDS

L. David Minsk

October 1975

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The effect of snow and ice on the operation and maintenance of a subsurface missile system was investigated during the construction stage of the Grand Forks Safeguard system site. Meteorological observations were made daily from 1 November to the following 30 April for the two winters 1971-72 and 1972-73, and compared with observations made at the 1st order stations of Minot and Grand Forks, North Dakota, west and east respectively of the Safeguard site. Though differences occurred, the climatic patterns at the 1st order stations were similar, and indicate that 25-40 snowstorms can be expected each winter, snowfall in a single storm may reach 11 in. each year, and 20 in. 1 year in 30. A full-scale model of a portion of the Spartan missile mound was constructed, as well as part of the double

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20. Abstract (cont'd)

chain link security fence and plywood models of six cell covers, and snow accumulation was observed during one winter. It was concluded that accumulation would never exceed the height of a cell cover, nor would snow completely bridge the pavement between cells. However, snow could accumulate to depths approaching 5-6 ft around the security fence under extreme conditions. When a hydraulic flume for conducting model tests for snowdrift potential became available late in the investigation, major structures at two of the radar installations were investigated, and a problem identified at one location. Performance tests were conducted on 12 models of 7-8 hp walk-behind snowblowers to evaluate the three tasks of lane, obstacle, and drift clearing which could be expected on the missile field. An analysis was made of the equipment requirements for snow clearance based on an estimate of accumulation on the site. Various plastic mesh materials were tested in a coldroom and in field trials for their performance as non-debris-forming snow fences, and satisfactory materials were found.

PREFACE

This report was prepared by L. David Minsk, Research Physical Scientist, Applied Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory. The work was done for the U.S. Army Engineer Division, Huntsville.

Meteorological observations were made by SSG Timothy C. Davis, SP4 James A. Boothe and SP5 Alfred M. Jesness, of the Atmospheric Sciences Laboratory, White Sands Missile Range. These data were analyzed and Section 2 of this report was prepared by Michael A. Bilello, Roy E. Bates and SP4 Alan Zenkel. Tests of small snowblowers were performed by Ben Hanamoto and Garv E. Phetteplace. The hydraulic modeling of snowdrifting was performed by Darryl J. Calkins. Gunars Abele technically reviewed this report.

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by

L. David Minsk

INTRODUCTION

Winter is a supreme test of the designer's art and the engineer's ability to ensure uninterrupted operations in a hostile environment far removed in time and place from that which existed during conception. Freezing rain, high winds, blowing and drifting snow, heavy snowfalls, fog – all may be expected in the northern United States, and all may have an adverse effect on military operations. At the request of the U.S. Army Engineer Division, Huntsville, acting for the Safeguard Systems Command, CRREL investigated the extent to which these conditions can occur at the Grand Forks Safeguard site. Under consideration were such factors as the frequency and duration of the conditions, and the design modifications and maintenance procedures which might be instituted to minimize their adverse effects on missile fields.

This is the final report of the project, which was initiated in May 1971 and carried through two winters of observation at Grand Forks Safeguard site, 1971-72 and 1972-73. During both winters, from 1 November to 30 April, a meteorological detachment from the U.S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, made daily observations of wind speed and direction, air temperature, precipitation, and snow on the ground. Observations were also made by CRREL personnel during portions of both winters. Snowdrift observations were made at Grand Forks during 1971-72 (there was insufficient snow during winter 1972-73 to obtain useful data) and tests of snow fence materials were made in both North Dakota and at CRREL in Hanover. Snow removal tests were conducted in both North Dakota and New Hampshire during winter 1972-73. In North Dakota a 1500-ton/hr rotary plow was mounted on a front-end loader and a blade plow was mounted on a tracked low ground pressure vehicle. At Hanover small pedestrian-type snowblowers were used. Low snowfall in North Dakota resulted in little data from those tests. Snowdrift potential and general configuration of expected snow accumulation around the major structures at the Perimeter Acquisition Radar (PAR) and Missile Site Radar (MSR) were determined by a model study using a hydraulic flume. This report summarizes the results of the field investigation, climatological study, equipment tests, and the snowdrift model study, and makes recommendations for a rational approach to missile field snow and ice control.

1. SNOWDRIFT POTENTIAL

MSR and collocated missile field

The nature and extent of drifting on the missile field, particularly on the Spartan field, was such an unknown factor, and potentially of such serious consequences, that a portion of the Spartan field

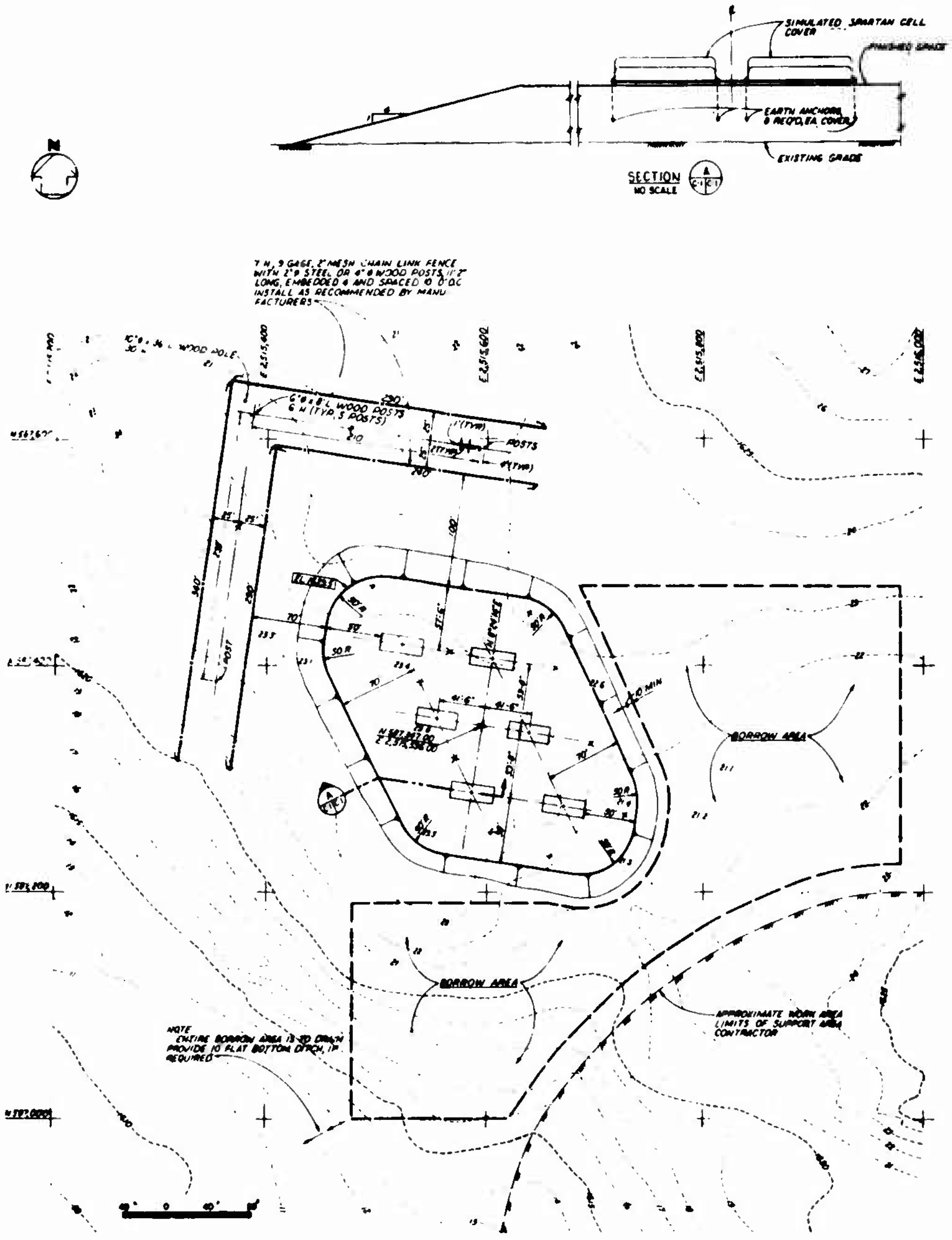

Figure 1. Model missile mound and double security fence.

was modeled in full scale on an earth fill simulating the operational missile mound. In addition, a corner portion of the double security fence, two rows of 7-ft-high chain link fabric spaced 50 ft apart, was installed north and west of the mound to determine snowdrifting in the vicinity of the fence, and the influence of the fence structure on snowdrift formation on the missile field. The site was near the operational missile field and was unobstructed to the west, north and east, directions from which the winter storm winds were expected. Structures and construction materials to the

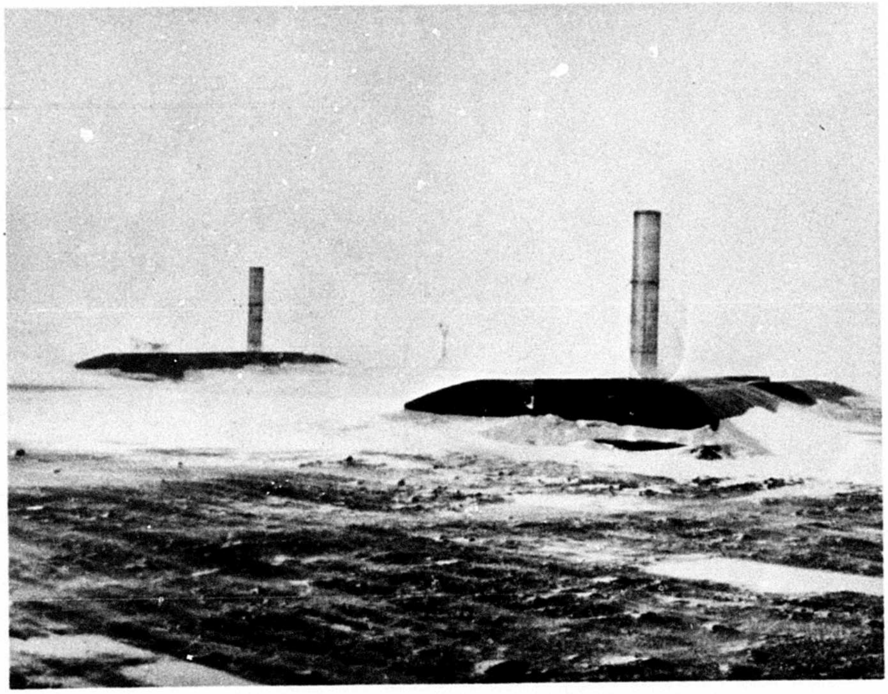

Figure 2. Cover no. 4 (at right) during storm of 23 February 1972, view WSW.

south were at least 600 ft away, and were not a serious interference. The mound was designed with a 1:4 slope, and a height of approximately 5 ft above surrounding grade was chosen for windblown snow to accumulate on the northwest portion of the field. Only six launch stations (12 covers) were required to study the influence of staggered rows of covers upon one another, thus minimizing the size of the mound and the number of covers (Fig. 1).

A full-size cover was designed to simulate the aerodynamic shape of the operational cover; it was considered unnecessary, because of the large size and small turbulence which would be generated, to fair the compound curves. This design allowed the use of plywood sheets nailed over curved webs for low material and construction cost. The Spartan antenna, an 18-in.-diameter by 11 ft 3 in. cylinder, was modeled using galvanized smoke pipe, guyed with three cables. The cover actuator cylinders were made of 4-in.-diameter smoke pipe.

Observations of accumulation were made daily from the time of completion of the simulated missile field on 12 November 1971 to the end of April 1972. Daily depths in inches at snow stakes on the field, and between the fence and mound, are given in Appendix A. The maximum depth measured was 27 in., at a point near the inner security fence. Drift from around the Spartan covers may be seen in the photographs (Fig. 2-8). The relatively smooth aerodynamic form of the cover, coupled with the high incidence of winds during and after snowfalls, prevented the accumulation of snow above the high point (center) of the cover, and at no time did drifts bridge the gaps between adjacent rows of covers. Snow accumulated both on the upwind and downwind faces of the cover to provide a smooth, unbroken surface (Fig. 4). Accumulation in the vicinity of the double security fence is shown in Figures 9-11.

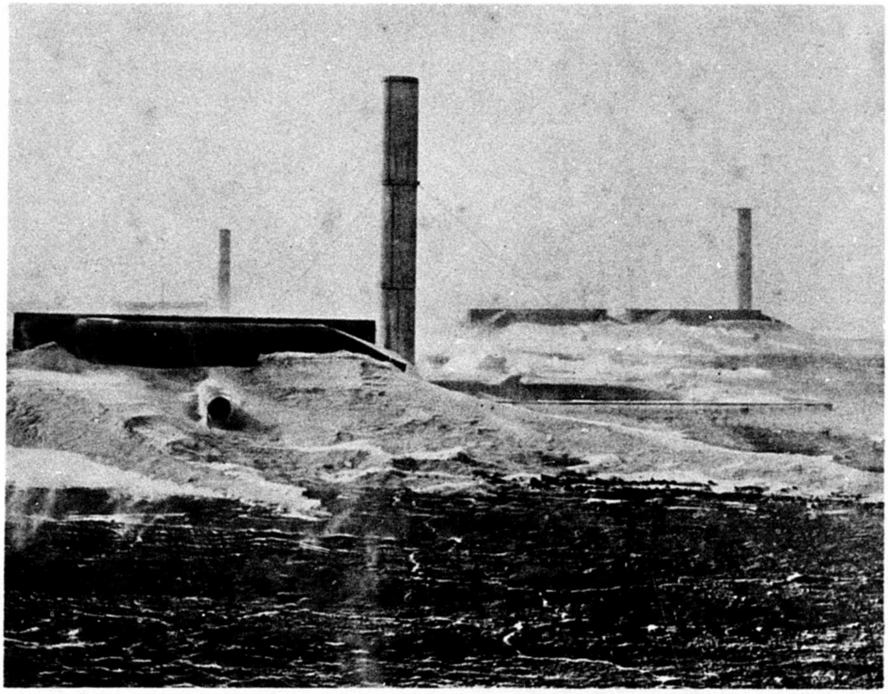

Figure 3. Cover no. 2 (at left) during storm of 23 February 1972, view S.

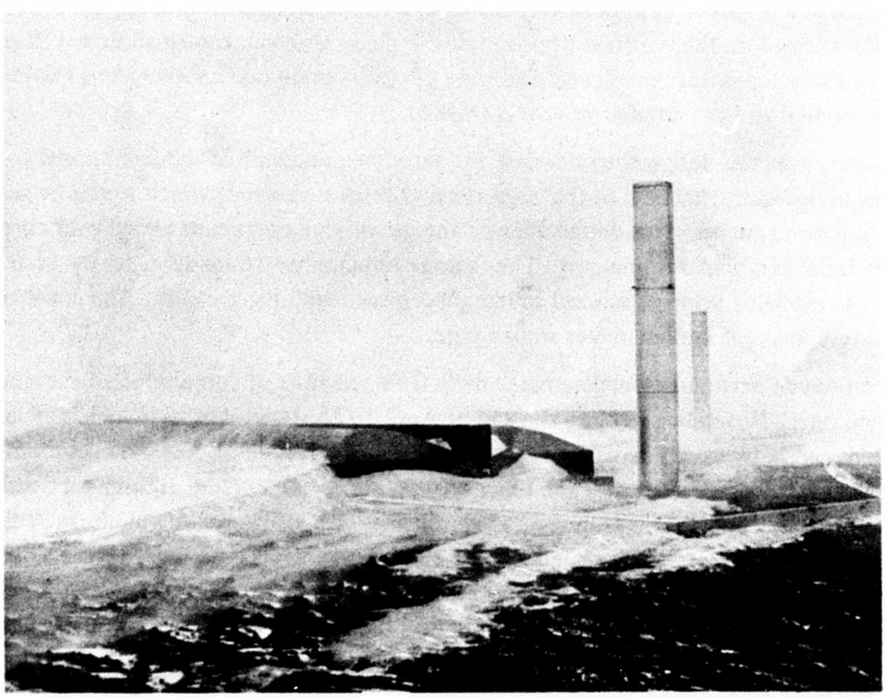

Figure 4. Flow of snow over cover no. 4 during storm of 17 February 1972, view SE.

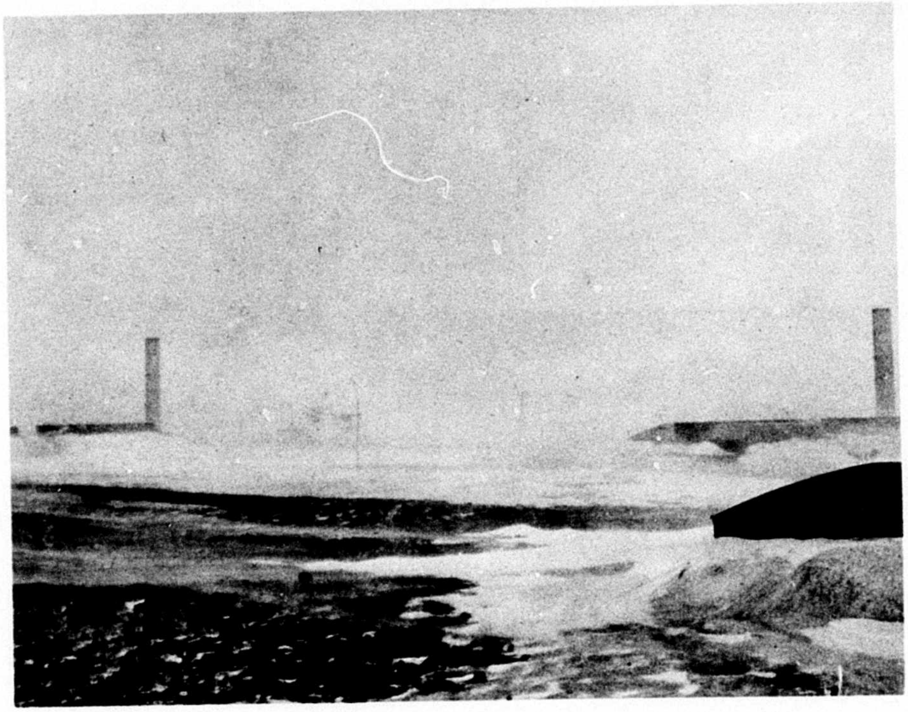

Figure 5. Edge of cover no. 2 (at right) during storm of 17 February 1972, view SSW. Slight accumulation (less than 1 in.) evident around snow stake B2 in center.

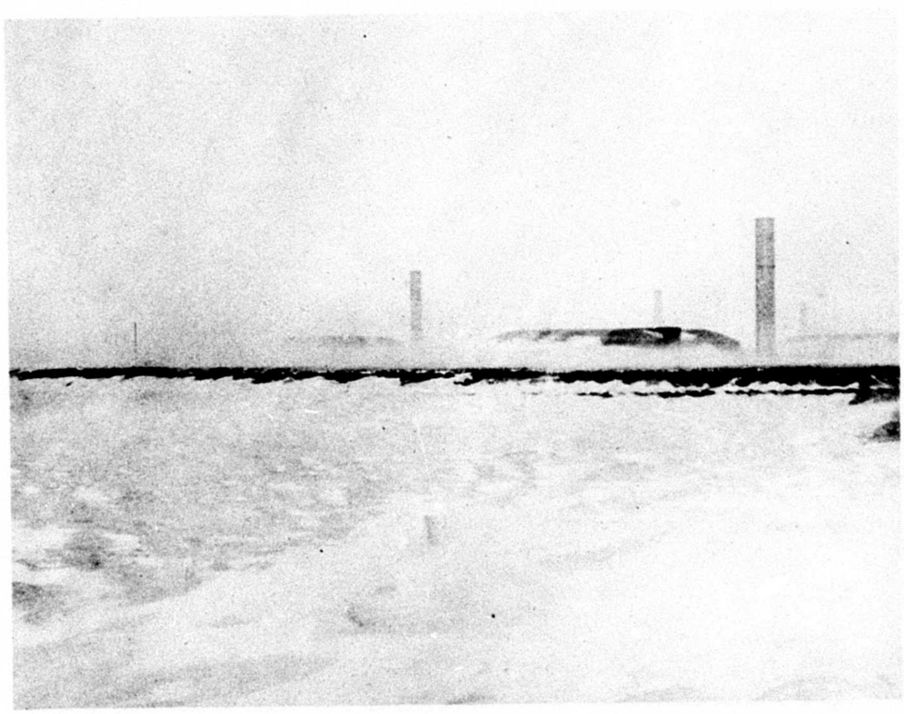

Figure 6. Accumulation on toe of north side of missile mound during storm of 17 February 1972, view SE. Wind scoured the lip and the drifts never carried onto the mound.

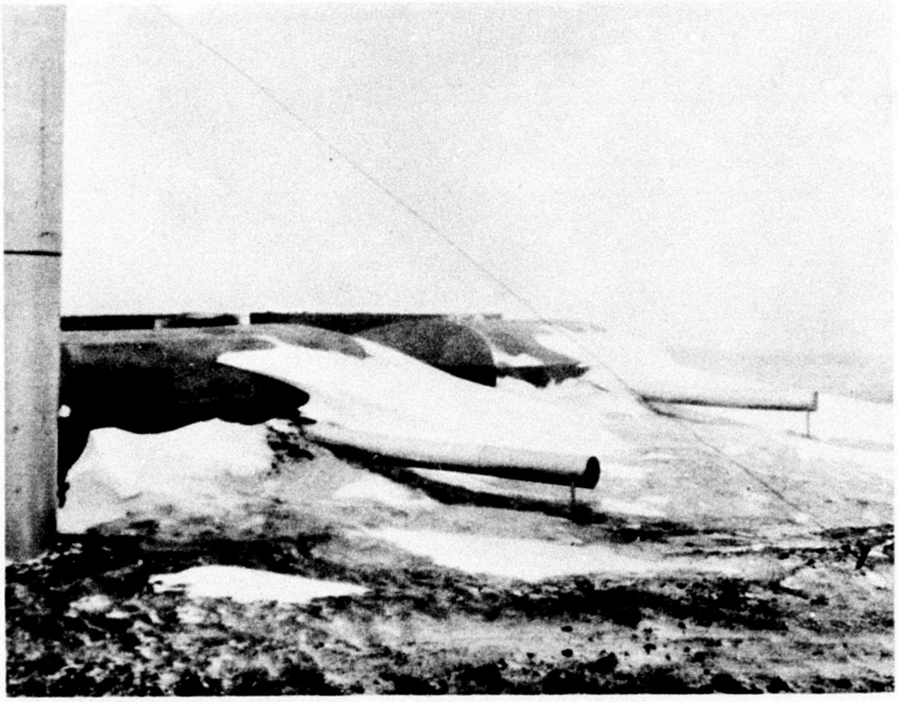

Figure 7. Accumulation on leeward (southward) side of cover no. 2 during storm of 17 February 1972, view NE.

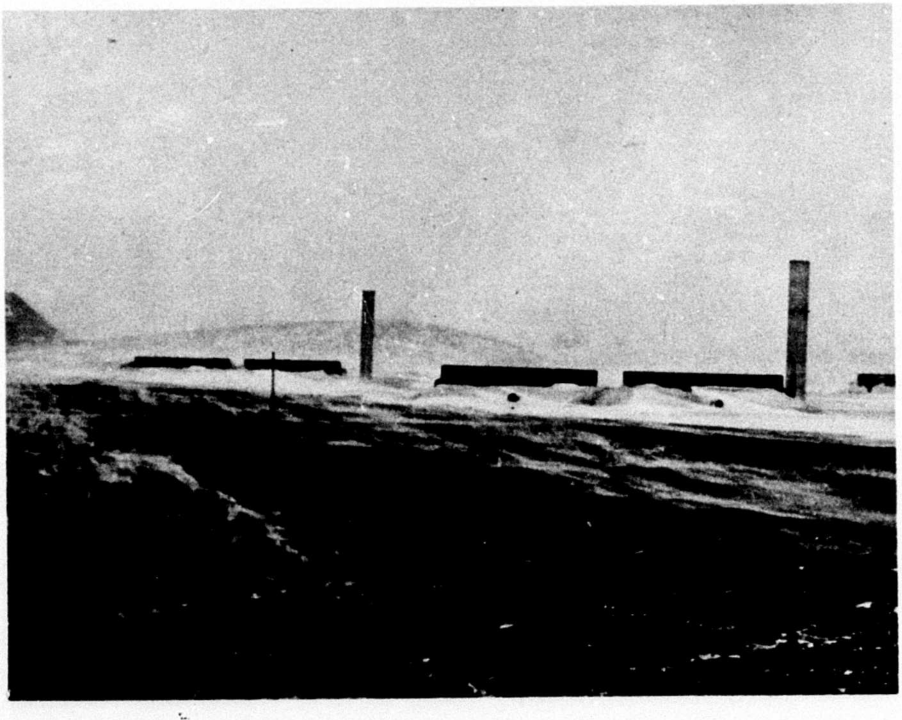

Figure 8. Flow of snow across missile mound past cover no. 4 (at right) with no accumulation during storm of 17 February 1972, view S. Snow stake C2 at left.

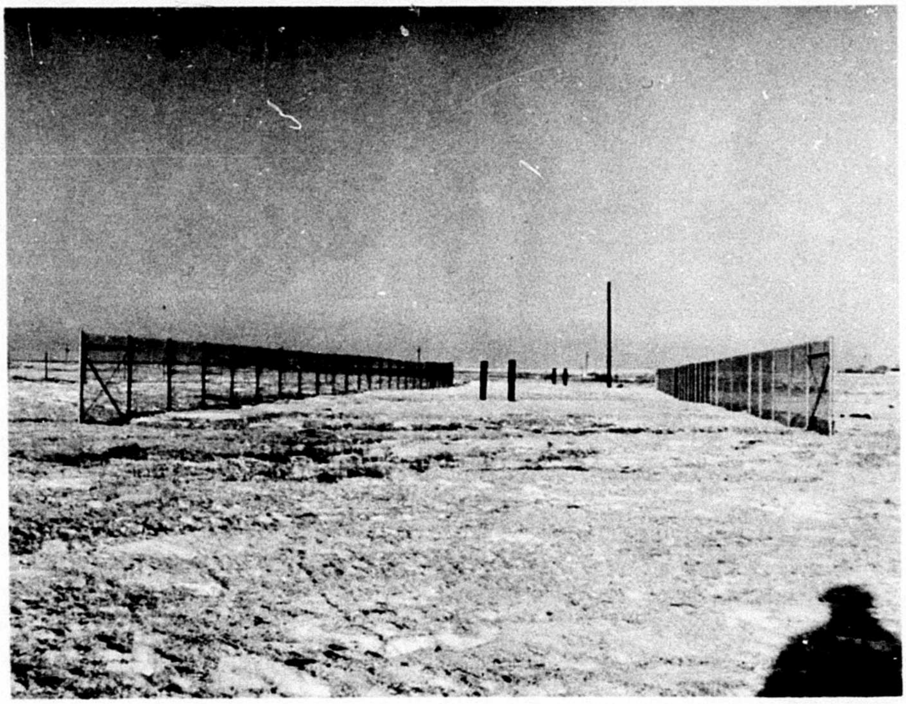

Figure 9. East-west line of double security fence, 13 March 1972, view W. Maximum depth at apex 24 in.; deepest on rest of east-west line 18 in. at this time.

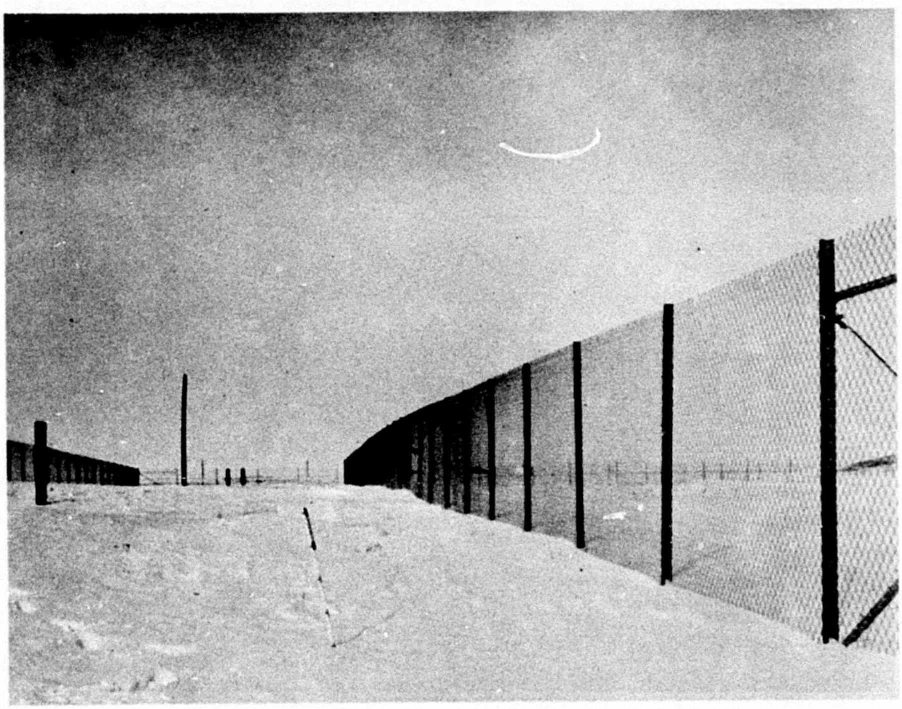

Figure 10. North-south line of fence, 24 February 1972, view N. Inner fence (and missile mound) at right. Snow depth at rule in center 12 in.

Figure 11. View NW from missile mound with accumulation in toe, depth 27 in., 18 February 1972

Figure 12. Hydraulic flume used for simulating snowstorms; sand simulates snow.

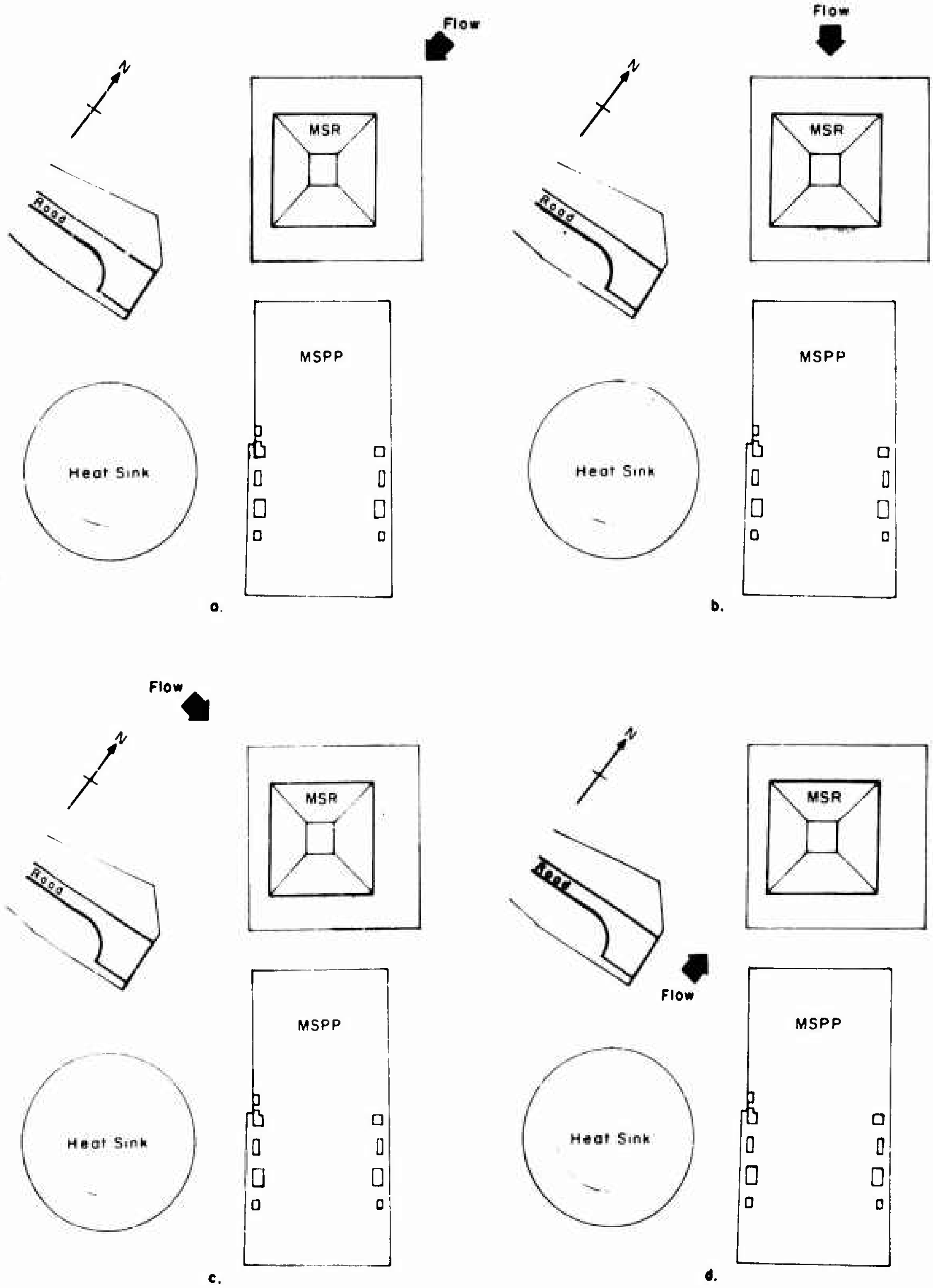

Figure 13. Areal distribution of sand accumulation in model tests simulating deposition of snow; accumulation appears to be potentially most serious on the MSPP depressed access road. (From Calkins 1974a.)

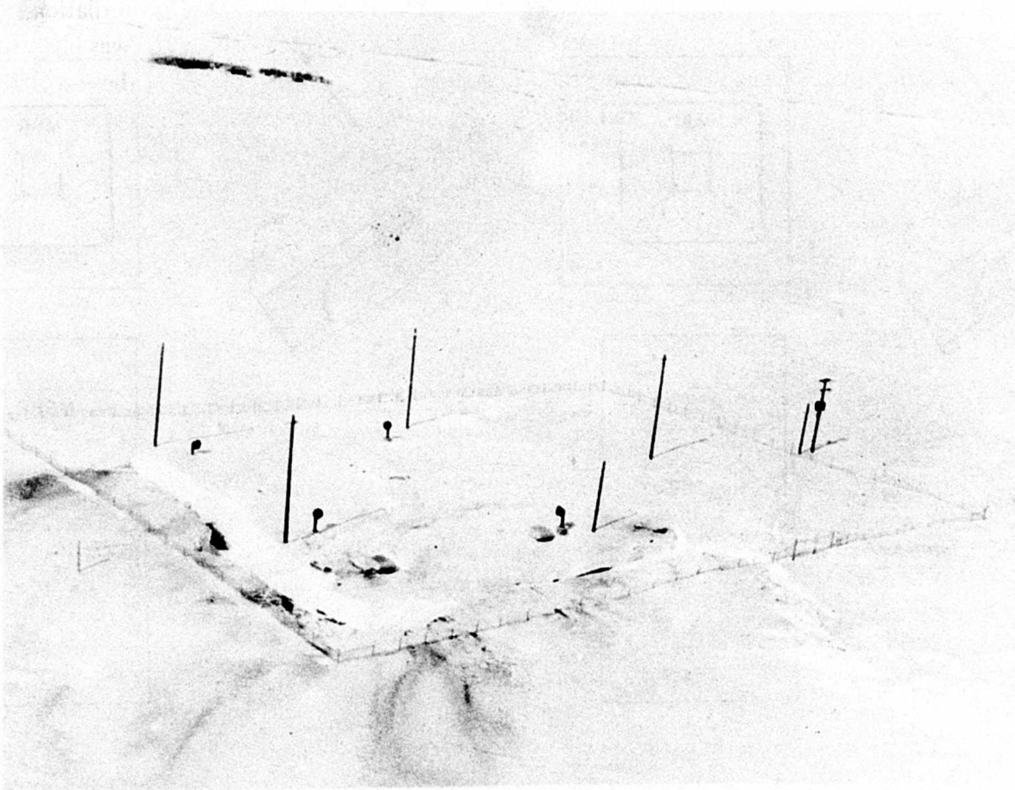

Figure 14. Snow accumulated at Minuteman site B-18 (3 miles east of Langdon, North Dakota) by chain link fence, 13 March 1969.

Figure 15. Snow removal on ND5 near Langdon, North Dakota.

Snowdrift potential in the vicinity of the MSR, Missile Site Power Plant (MSPP) ventilation stacks, MSR depressed tunnel access, and the Perimeter Acquisition Radar Building (PARB) was investigated by model studies in a hydraulic flume using sand to simulate snow. Scale models of these structures were constructed of wood or Plexiglas and the influence of building shape, orientation and topography on the deposition pattern observed. The flume, installed at CRREL and placed in operation after the field investigation had ended, is shown in Figure 12. Sand is introduced into the water at the upstream (right) side, and is transported to the model which is fixed to the bottom of the flume near its center. At present only areal distribution of snowdrifts can be predicted as a function of wind speed and direction; simulation of depth and prediction of depth in the field must await development and evaluation of scaling laws.

The results of the study were reported in detail by Calkins (1974a). Briefly, the model studies show the potential for large snow accumulation behind the PARB and MSR, but there appears to be sufficient storage capacity for the snow. Snow will accumulate against the faces or sides of these structures when the flow direction is not normal to one of the sides. Only one trouble area was indicated in the study: the depressed tunnel access to the MSPP (Fig. 13). The model study suggests that an appreciable amount of snow will accumulate in that location, though the extent and precise location could not be determined. Wind speeds modeled correspond to a full scale range of 23.5-37 mph (10.5-16.5 m/sec).

PAR area

No continuous field observations were made of snowdrifting at the PAR. A model study performed with the PARB alone indicated that drifting around it would not be extensive (Fig. 13).

Remote Sprint Launch (RSL)

Construction at all RSL's prevented any clear-cut determination of drifting patterns and depths which could be expected. However, based on analogies with the MSR area, drifting on the Sprint field itself will be minor and only access roads downwind of the Remote Launch Operations Building (RLOB) will be affected to any serious extent.

Historical perspective

The climatology of the Grand Forks Safeguard Site region is given in Section 2. However, it is worthwhile at this point to describe some of the extreme snowdrifting situations which have occurred in the area in past years. In this connection, it should be realized that chain-link fences, which ordinarily offer little obstruction to any windblown snow, can become blocked with wet snow and cause massive drifting. This is illustrated by the heavy drifting at Minuteman site B-18, located 3 miles east of Langdon on ND5, where on 13 March 1969 snow nearly buried a portion of the security fence (Fig. 14), a not uncommon incident. The blizzard of 2-5 March 1966 left drifts up to 20 ft deep in many areas of eastern North Dakota; clearance operations on ND5 15 miles east of Langdon are shown in Figure 15.

2. CLIMATOLOGY OF THE GRAND FORKS REGION

Daily observations of temperature, wind, and the various types of precipitation were made at Nekoma from 1 November 1971 to 30 April 1972, and from 1 November 1972 to 30 April 1973, and compared with similar records from Grand Forks and Minot, North Dakota. Station locations are shown in Figure 16.

Table I. Monthly weather summaries for North Dakota sites.

		Temp (°F)			Precip (in.)		Max	Total hours of weather types*†								Wind (kt)		
Month	Station	Max	Min	Avg	Total	Snow	SOG†	S	R	L	IP	ZL ZR	F	BS DS	IC IF	Avg speed	Prin dir	Peak gust
Nov 1971	Nekoma	42	−19	23	0.62	2.0	3	78	12	60						8	NE,NW	33
	Grand Forks	46	5	28	0.27	1.8	5	75	3	12		7	90	17	18	10	NW	49
	Minot	55	2	27	0.22	1.9	2	148	4	18		5	64	14	26	9	NW,SE	53
Dec 1971	Nekoma	32	−20	7	0.23	4.4	5	72	0	12						7	NW,SE	28
	Grand Forks	33	−13	11	0.19	4.7	3	106	0	0		31	113	31	20	7	WNW	31
	Minot	37	−17	9	0.20	2.0	2	106	0	0		21	54	7	36	9	WNW	32
Jan 1972	Nekoma	38	−37	−3	0.31	11.0	9	84	0	0						9	NW	36
	Grand Forks	38	−31	1	0.18	5.6	4	121	0	0		0	0	116	0	9	WNW	48
	Minot	45	−32	4	0.43	4.2	2	152	0	0		1	0	49	51	12	NW	43
Feb 1972	Nekoma	39	−27	1	0.62	13.0	13	114	0	0						8	WNW,SE	26
	Grand Forks	37	−21	4	0.31	6.1	4	178	0	0		5	21	47	17	8	NNW	41
	Minot	43	−26	4	1.07	11.3	7	217	0	0		2	0	43	171	10	NW,E	58
Mar 1972	Nekoma	45	−26	19	0.62	14.2	18	48	6	6						8	NW,SW	41
	Grand Forks	51	−20	22	0.70	13.2	9	93	7	6		0	76	65	4	9	NW	51
	Minont	56	−24	23	0.96	7.9	9	131	10	33		3	85	30	90	10	WNW,SE	51
Apr 1972	Nekoma	63	3	36	0.62	2.6	12	42	26	10						7	NW,SSE	30
	Grand Forks	66	11	38	2.55	10.6	3	33	34	14		1	42	2	0	10	NW,SSE	33
	Minot	66	13	40	0.65	4.5	4	20	29	19		4	91	0	0	11	WNW	37
Nov 1972	Nekoma	37	− 8	21	0.68	3.0	8	186	3	15		27	36	18		8	NW,SSE	35
	Grand Forks	50	− 2	26	0.08	1.5	2	76	3	5		8	86	3		8	SSE	38
	Minot	48	− 7	24	0.36	5.9	4	140	2	4	2	16	80	5	5	7	NW,SE	37
Dec 1972	Nekoma	33	−28	0	1.57	6.3	7	180				18	18			9	WNW	43
	Grand Forks	37	−19	6	0.56	8.5	9	114			4	20	74	41	21	10	N,SSE	45
	Minot	41	−27	5	0.44	4.3	5	76	1		1	13	35	21	32	9	WNW,SE	39
Jan 1973	Nekoma	42	−29	11	0.35	1.0	7	120				24	12	24		9	NW,SSW	40
	Grand Forks	44	−26	12	0.09	1.4	9	56			1	8	64	28	26	9	NNE,S	43
	Minot	46	−25	16	0.13	1.0	3	53	1			10	23	7	40	8	NW	38
Feb 1973	Nekoma	42	−22	12	0.36	1.4	2.5	114				21	18	48		11	N,ENE	36
	Grand Forks	43	−14	17	0.07	1.1	1	48		1		16	104	59	14	10	S,NNW	42
	Minot	48	−20	17	0.17	3.5	3	86		1		15	61	24	21	9	NW	40
Mar 1973	Nekoma	57	12	32	0.96	3.8	2	72	18	15		12	60			10	SE,NNW	38
	Grand Forks	59	22	36	1.04	2.7	1	37	17	18	5	9	195			9	S	38
	Minot	68	15	35	0.28	2.1	2	40	13	14			87			7	SSE,NW	40
Apr 1973	Nekoma	69	10	37	0.60	0.6	.5	30	30	9			24			11	N	45
	Grand Forks	75	12	41	0.37	0.7	1	11	13				8			12	S	56
	Minot	79	10	40	1.32	3.5	1	36	33	8			19			8	NW,SE	45

* For Grand Forks and Minot, N.D. – When two or more weather types occurred concurrently, the number of hours for each type was counted separately. Periods with a trace of precipitation were also counted at all three sites.

For Nekoma, N.D. – No continuous detailed information on weather types was recorded; consequently, estimates were made of weather types from 6-hour observations and temperatures. Some 3-hourly observations were also used when available.

† SOG Snow on ground; IP Ice pellets; ZL Freezing drizzle; ZR Freezing rain; F Fog; BS Blowing snow; DS Drifting snow; IC Ice crystals; IF Ice fog

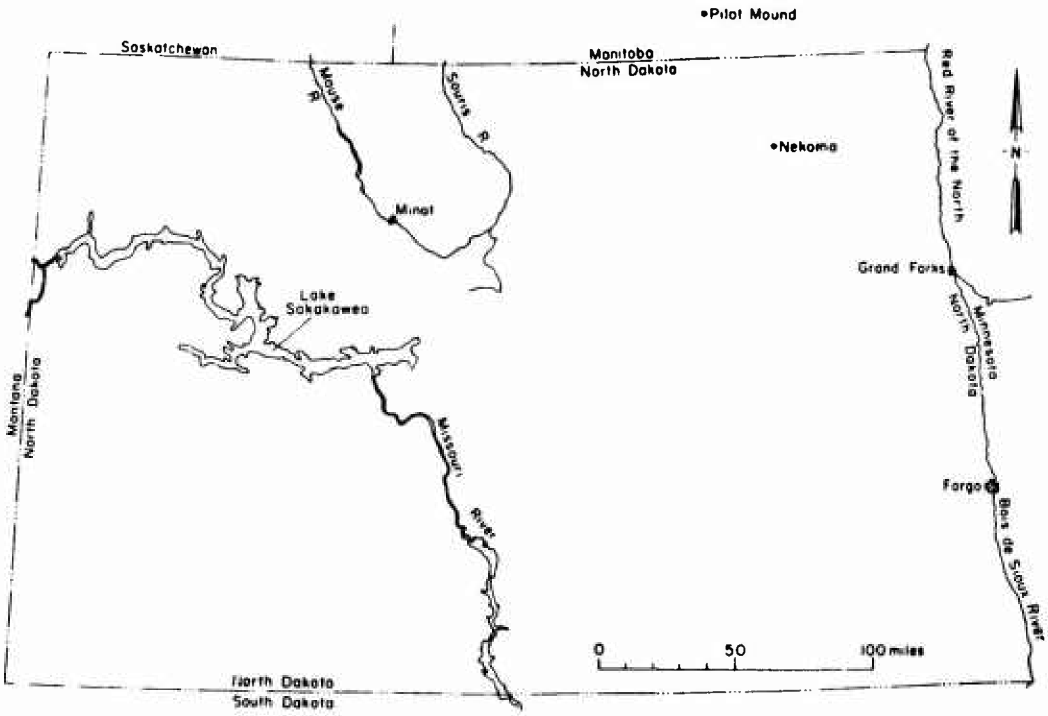

Figure 16. Locations of meteorological stations.

The daily data were reduced to monthly summaries to permit meteorological and climatological comparisons to be made between the sites. The results for the two years of observations are given in Table I. The average monthly temperature is the arithmetic mean of the daily maximum and minimum temperatures. The "total" precipitation is the amount of water accumulated from all types of precipitation during the month. "Snow" is the snowfall amount which accumulated during each snowstorm through the month, and the "maximum snow on the ground" (SOG) is the deepest snow reported at the weather site during the month. The selected snow depth measurement sites are in areas generally not prone to snow erosion or drifting. Snowfall was extremely light at the three climatic stations during the 1972-73 winter. Since all weather types were not measured hourly at Nekoma, the number of hours of freezing and non-freezing forms of precipitation for that site were estimated. The estimates were made by considering the weather conditions at Minot and Grand Forks in conjunction with observed periods of precipitation and concurrent freezing air temperatures at Nekoma. The peak gust is the maximum instantaneous velocity recorded during the month.

Wind speed and direction were similar at all three stations. Monthly wind directions throughout winter 1972-73 at Grand Forks were often southerly, a condition which is not the norm. Since the terrain in this area is quite level, the south winds are mainly the result of the high- and low-pressure weather systems which traverse the region. It seems apparent therefore that the area generally experiences an idealized sequence of synoptic winter weather conditions, i.e. prefrontal, snow-bearing southerly winds followed by a frontal passage and stronger, colder and drier winds from the west and northwest, which generally cause snow drifting.

Unfortunately, the wind recording equipment at Nekoma occasionally failed to operate. The systems were not dependable during periods of blowing snow, freezing rain or freezing drizzle; they also experienced occasional electrical and bearing problems.

Table II. Estimated average climatic conditions at Safeguard site northwest of Grand Forks, N.D.

Period of record – 1931-1960 taken from nearby stations.
Elevation – 800-1600 feet.

	Temperature (°F)				*Precipitation (in.)*[a]			*Humidity (%)*[d]	
				Mean no.				*Mean monthly*	
Month	*Mean max*	*Mean min*	*Mean monthly*	*days min < 32°F*	*Mean monthly*	*Max monthly*	*Max*[e] *24 hr*	*0600 LST*	*1800 LST*
Jan	11	−10	1	31	0.6	1.4	0.7	70	69
Feb	16	− 5	6	28	0.5	1.3	1.2	75	73
Mar	30	9	19	28	0.7	2.3	1.2	83	71
Apr	50	28	39	18	1.1	3.1	1.9	82	60
May	67	39	53	4	1.6	4.1	2.4	77	47
Jun	74	48	61	0	2.9	5.5	2.8	81	54
Jul	82	54	68	0	2.8	5.5	3.9	86	54
Aug	80	52	66	0	2.4	6.0	4.7	87	51
Sep	70	42	56	2	1.7	6.3	4.0	88	59
Oct	56	31	43	12	1.2	4.8	1.3	81	58
Nov	33	14	23	26	0.6	3.2	1.6	81	70
Dec	19	− 1	9	31	0.5	1.3	0.9	77	75
Extreme max 109			Mean annual	Total mean annual	Total mean annual	Max total annual			
Extreme min −49			37	181	16.6	25.1			

	Wind (mph)				*Snowfall (in.)*			*Snow on ground*
	Mean monthly	*Prevailing*	*Fastest mile*[b]					*Max monthly depth 1953-56*
Month	*speed*	*direction*	*Speed*	*Direction*	*Mean monthly*	*Max monthly*[e]	*Max*[e] *24 hr*	*(in.)*
Jan	12.7	NW	52	N	6.8	14.9	6.8	26
Feb	12.2	NW	51	NW	5.7	15.8	11.2	26
Mar	12.8	NNW	58	N	7.5	15.4	8.0	28
Apr	14.0	N	59	NW	3.1	12.4	7.4	24
May	13.1	N	61	NW or SSE	0.7	1.0	1.0	2
Jun	11.6	SSE	65	SW	T	0	0	T
Jul	10.1	S	68	NNW or S	T	0	0	0
Aug	10.6	SSE	58	NNW	0	0	0	0
Sep	12.0	SSE	72	NW	0.1	0.6	0.6	T
Oct	12.6	SSE	56	WNW	1.5	8.1	7.8	8
Nov	13.2	NW	65	NW	5.1	19.8	10.9	19
Dec	12.1	NW	55	N	5.6	20.3	5.7	20
Annual	12.3	NW	72	NW	Total mean annual 36.1	Max total annual 82.2		

Short duration[e] *and extreme*[c] *snowfall amounts (in.)*						
6 hr max water equiv (1951-60)	*6 hr max total "catch" (1951-60)*	*24 hr extreme total "catch"*	*Extreme single storm total "catch"*	*Extreme calendar month total "catch"*	*Extreme seasonal total "catch"*	*Max depth of snow on ground*
MSG	MSG	19.2	19.2 (1 day)	30.4 (Nov)	82.2 (1937)	27.8 (1897)

a. Includes water equivalent snowfall
b. Maximum one minute average recorded speed
c. Long term record
d. 7-year record, Fargo, N.D.
e. Fargo data.

Long-term monthly averages of wind speed and direction for several stations near Nekoma, derived in a previous study (Bilello et al. 1968), are shown in Table II. The average wind speed in this region of North Dakota from November to April is 12.8 mph and the prevailing wind direction is northwesterly. An analysis of individual snowstorms at each station showed that for those periods when snow is actually accumulating the stations experience similar total hours of snow time per year.

Observations winter 1971-72

The analysis of weather types at Nekoma was confined to snow, rain and drizzle. Nekoma experienced fewer total hours of snow during the winter of 1971-72 than the other sites (Table I). This difference is probably due to the fact that Grand Forks and Minot reported periods with a trace of snow, whereas Nekoma reported only the periods with measurable snow.

Neither rain nor drizzle was observed during January or February 1972 at the three sites. However, the weather records from Grand Forks and Minot indicate that freezing rain and freezing drizzle can occur in the area at any time in winter. This phenomenon was observed most frequently in December at both sites, and one such storm at Grand Forks continued for almost 30 hours.

Fog, blowing or drifting snow, and ice fog or ice crystals also occur frequently in this area in winter (Table I). Although data for these parameters were not available for Nekoma, the conditions reported at Grand Forks and Minot are probably similar to those occurring at Nekoma, which is located between these two stations (Fig. 16).

A detailed analysis was made of all significant snowstorms observed at the three stations, and all drifting or blowing snowstorms and freezing drizzle or freezing rainstorms observed at Grand Forks and Minot during the winter of 1971-72 (Appendix B, Tables BI-BIV). A "significant snowstorm" excluded periods when only a trace of snow was recorded or when the visibility was over six miles. For Grand Forks and Minot this tabulation also included periods of light snow, snow showers, snow grains, and ice or snow pellets. Appendix B shows that in most instances when snow is reported at one location, it is also reported at one or both of the others. Only a few exceptions were noted; for example, snow was observed only at Nekoma during 21-23 November 1971 and 17 April 1972, and only at Minot during 5-8 February and 17 March 1972. Both duration and amounts of snow at all three stations during major snowstorms are similar. Good examples are the lengthy snowstorms recorded near the end of February and March. These associated facts indicate that the three sites have similar winter weather.

Blowing and drifting snow, freezing rain and freezing drizzle were not recorded at Nekoma; therefore comparisons of these events were made between Grand Forks and Minot only. During the winter of 1971-72 similar conditions occurred at these two sites, except that more blowing and drifting snow was recorded at Grand Forks than at Minot. Table BIV shows a high incidence of blowing and drifting snowstorms, and their length indicates that they can create serious problems.

The number and duration of snowstorms, blowing and drifting snowstorms, freezing drizzle and freezing rainstorms are given in Table III. Snowstorms over 30 hours long were observed at all three stations during the 1971-72 winter. The most prominent one occurred between 25 and 28 March 1972, when 5 to 8 in. of snow fell at the stations. Although Nekoma had more individual snowstorms during the winter than Grand Forks or Minot, the latter sites had more storms that continued for 12 hours or more. These variations may be due to the fact that the Nekoma site was not manned for 24 hours every day (as were the other sites), so that observations were made every 6 hours instead of every hour. From 25 to 40 snowstorms can be expected each winter, and based on Minot and Grand Forks data many will last more than 12 hours. It is estimated that up to 11 in. of snow in a single storm can accumulate each year and a 20-in. accumulation of snow in a 24-hour period can be expected 1 year in 30.

Table III. Number and duration of snow, blowing and drifting snow and freezing drizzle or freezing rainstorms at North Dakota sites, November through April.

Station	*< 6 hours duration*	*6 to < 12*	*12 to < 18*	*18 to < 24*	*24 to < 30*	*30 to < 36*	*≥ 36 hours*
Snowstorms, 1971/72							
Nekoma	18	18	2	1	1	1	0
Grand Forks	8	6	5	2	0	2	1
Minot	11	9	6	4	1	1	1
Snowstorms, 1972/73							
Nekoma	20	9	6	5	1	1	2
Grand Forks	30	19	3	1	1		
Minot	37	12	4	2	3	1	1
Blowing or drifting snowstorms, 1971/72							
Grand Forks	17	11	5	2	1		
Minot	11	7	1	2	0		
Blowing or drifting snowstorms, 1972/73							
Grand Forks	6	4	2	3			
Minot	7	2	1				
Freezing drizzle or freezing rainstorms, 1971/72							
Grand Forks	6	1	0	0	1		
Minot	7	1	1	0	0		
Freezing drizzle or freezing rainstorms, 1972/73							
Grand Forks	13	3					
Minot	11	3					

Table III shows 36 cases of blowing or drifting snow at Grand Forks and 21 at Minot. About half of these events lasted less than 6 hours and a few more than 18 hours. Freezing rain and freezing drizzle were observed a total of eight and nine times during the winter at Grand Forks and Minot, respectively. Most of these storms were less than 6 hours long, but a major storm of this type should be expected occasionally, such as the one observed on 22-23 December 1971. Considerable icing or glaze, naturally, could be expected to form on antennae and other structures during these storms. Similar storm conditions and resultant weather (especially over a long-term period) can be expected at all three North Dakota sites. Minor storms may produce slightly different weather conditions from hour to hour or day to day at each site, but major storms generally produce similar results.

Observations winter 1972-73

Similarities in the weather at the three stations were not as definite in 1972-73 as in 1971-72. Air temperatures at Nekoma for the 6-month period averaged 4°F lower than at Minot or Grand Forks. The maximum temperatures at Minot during December, March and April were 10°F higher than at Nekoma, and the maximum temperatures at Grand Forks in December and April were respectively 13°F and 6°F higher than at Nekoma. Although snowfall during 1972-73 was light, highest monthly amounts were recorded at Minot in November and at Grand Forks and Nekoma in December; lowest amounts were reported at Grand Forks and Nekoma in April. Minot recorded 20 in. of snow during 1972-73, 4 in. more than was recorded at either of the other sites. These amounts are considerably below the seasonal normal snowfall expected in the area (Table II). Winds for the three sites during the winter of 1972-73 averaged between 7 and 12 kt, mainly from the northwest or southeast. Monthly peak gusts ranged from 35 kt at Nekoma in November to 56 kt at Grand Forks in April.

The area had less snow and higher temperatures than normal; consequently reports of blowing and drifting snow at the three weather stations were infrequent.

Since detailed hourly weather observations were not available for Nekoma, the analysis of weather types at this site was limited to precipitation time periods of 6 hours. Some 3-hourly observations were also made during the daytime at Nekoma. This information was meager, but was used in the summaries when provided. The summaries in Table I show that Nekoma experienced more hours of snowfall than the other two sites. However, the comparison is not necessarily valid because of the 3- and 6-hourly precipitation intervals used for Nekoma. The summaries for hours of snowfall at Minot and Grand Forks in Table I also include periods of traces of snowfall. Incidentally, an analysis of individual snowstorms at each station showed that when snow was accumulating on the ground, the duration of the snowstorm was similar for all stations.

During winter 1972-73 the periods of freezing rain and freezing drizzle lasted longer at Nekoma during November, January, February and March than at the other two sites. This situation again is possibly due to the fact that 3- and 6-hour periods were counted at Nekoma, whereas the exact time that precipitation began and ended was recorded at the other sites.

Fog, blowing or drifting snow, and ice fog or ice crystals occurred frequently during the winter of 1972-73 (Table I). Fog occurred more frequently in 1972-73 than in 1971-72, especially during January and February. This condition may have been due to the higher average air temperatures (approximately 12°F higher observed during both these months in 1973). Total hours of ice fog and ice crystals for the season also were less, again a reflection of the warmer conditions during 1972-73. The highest monthly total hours of drifting or blowing snow in 1972-73 was 66 hours observed at Nekoma in December; this compares with 116 hours previously observed at Grand Forks in January 1972. As noted already, the decrease in blowing and drifting snow in 1972-73 is probably due to a lack of snow cover and higher air temperatures.

The snowstorm tabulation (Table BVIII) includes all periods of light snow (i.e. traces), snow showers, snow grains, and ice or snow pellets. In most cases when one form of precipitation was occurring at one location, a trace or more of precipitation occurred at at least one of the other two sites. However, some significant differences were noted in snowfall amounts and duration for some storms. For example, between 28 December 1972 and 1 January 1973, a snowstorm lasted intermittently for over 100 hours at Nekoma, for 61 hours at Grand Forks and for 46 hours at Minot. In terms of inches of water equivalent, this snowstorm produced 1.43 in. at Nekoma, 0.46 in. at Grand Forks and 0.14 in. at Minot. During another snowstorm between 5 and 7 March 1973 Nekoma observed 48 to 54 hours of snowfall with a water equivalent of 0.57 in., while Grand Forks observed 20 hours of snowfall (water equivalent 0.14 in.), and Minot 32 hours of snowfall (water equivalent 0.21 in.).

Visual observations of blowing and drifting snow and freezing drizzle and freezing rain were apparently insufficient at Nekoma, very few of these events being reported. Consequently, comparisons of these events were limited to Grand Forks and Minot. The analysis made for the previous winter showed that these weather occurrences were similar at these two sites. Comparisons for the winter of 1972-73 showed less similarity in these four weather events, since they occurred 16 times at Grand Forks, 10 times at Minot, and only 14 times concurrently at both sites. Blowing snowstorms throughout the winter were reported five more times and observed for a total of 78 more hours at Grand Forks than at Minot (see Table I). Over twice the number of hours of blowing or drifting snow was observed at Grand Forks the previous year; in the winter of 1971-72 the station reported 278 hours and in 1972-73 only 131 hours.

A compilation of the number and duration of snowstorms, blowing and drifting snowstorms, and freezing drizzle and freezing rainstorms is given in Table III. As noted earlier, information only on snowstorms was available for Nekoma. Snowstorms of 24-hour duration were observed at all three stations during the 1972-73 winter. Nekoma had two snowstorms which lasted intermittently for 36 hours and Minot recorded one such storm. The most prominent storm occurred between 29 December 1972 and 2 January 1973, when 3 to 8 in. of snow fell at all stations. Since this was a generally light year for snow, trace amounts were also included as part of each storm. The number of storms in 1972-73, therefore, varied from a low of 44 at Nekoma to a high of 60 at Minot. It is possible that more short-duration storms occurred at Nekoma but they were not detected because the station did not make hourly observations. From the snowfall and snowstorm information gathered during 1972-73, the statement previously made that up to 11 in. of snow in a single storm can accumulate each year and a 20-in. accumulation in a 24-hour period (approximately 1 in./hour) can be expected 1 year in 30 appears valid (see Table II). It is stressed, though, that strong winds during or immediately after a snowstorm will cause serious drifting and snow accumulation problems, especially around obstacles and across roadways.

Table III shows 15 cases of blowing or drifting snow at Grand Forks and 10 at Minot; this is about half the number observed the previous winter. Most of these storms lasted less than 12 hours. Freezing rain and freezing drizzle were observed 15 and 14 times during the 1972-73 winter period (as compared to 8 and 9 times during 1971-72) at Grand Forks and Minot, respectively. Most of these storms were less than 6 hours long. Historically, however, storms of this type have lasted much longer (1 to 2 days). In general, major storms which influence a wide area cause precipitation at all locations in northeast North Dakota, but produce varying accumulations and last for different lengths of time. Minor local storm activity in winter results in one site recording precipitation while another does not.

Snow cover density was measured weekly during winter 1972/73 at Nekoma. Average monthly snow densities are:

Nov	0.27 g/cm^3	Mar	Not enough snow for measurement
Dec	0.24 g/cm^3	Apr	Not enough snow for measurement
Jan	0.30 g/cm^3	Avg	0.29 g/cm^3
Feb	0.34 g/cm^3		

These measurements are the average densities of two or three identifiable snow layers and were made only when the snow was deeper than 3 in. Many of the snow density measurements were taken in snowdrifts and wind slab areas. This information is useful in determining the type and size equipment needed for snow removal and control.

Wind chill factors* to be expected during working hours were computed for Nekoma. The following are the monthly average equivalent temperature values calculated for the period between 0900 and 1500 daily:

Nov	12°F	Feb	−5°F
Dec	−16°F	Mar	15°F (25 days only)
Jan	− 3°F		

* Wind chill is the effective low temperature (°F) when wind speed (mph) is considered in conjunction with air temperature (°F).

The lowest equivalent temperatures (wind chill) observed were −63°F at 0900 local time on 14 February 1973 and −62°F at 0900 on 6 December 1972.

The northeastern part of North Dakota experienced a mild winter during 1972-73. The air temperatures were above normal, snowfall was light, and the total hours of storminess (including blowing and drifting snow) were less than normal. In general, the three weather stations in the region again appear to experience similar weather conditions during the winter. Finally, the 1971-72 winter in northeast North Dakota was closer to normal than the 1972-73 winter.

3. CONTROL OF DRIFTING SNOW

Snow fences

The requirement that any structures or materials within a prescribed range of the MSR antenna be non-debris-forming made necessary the search for a suitable material to use for snow fences to be placed within that range. The common wood-slat fence was ruled out because of its high debris potential. Reinforced paper and plastic materials were investigated for durability under low temperature and high wind conditions, and for snow-collecting efficiency. Materials were screened in a coldroom for cold embrittlement, then successful materials were installed on fence posts both at CRREL and in a clear, windswept area in the vicinity of the Grand Forks MSR. The materials tested are listed in Table IV.

Two methods were used to attach the paper and shade material to the steel fence posts: 1) neoprene strips forming a sandwich around the fabric between the post and a clamped metal strip, and 2) wood dowels wired to the post, with the fabric clamped between the U-channel of the post and the dowel. The dowel method proved to be superior in two respects: 1) when properly fastened and when the proper size dowel was used in the U-channel, its clamping action was more certain and 2) it was faster and used less material (dowels used were broom handles cut to the required length). Neoprene sandwiches were used only for attaching the strips. Dowels were used for strip attachment as well as for the 45-48-in. widths. The lightweight (yellow) shade material was obtained in an 88-in. height for testing in North Dakota, but late delivery and the constant moderate to high winds prevented its emplacement. Experience in installing the fence materials showed that it is much more practical to attach two 45 to 48-in. heights to obtain the double height fence than it is to use the mill-made double height, especially in a windy location.

The most satisfactory material tested was the Vexar polyethylene waffle material (Fig. 17-18). More snow accumulated behind this material than behind all other materials and vertical spacing configurations. However, it was the heaviest material tested. Sag was noticeable at the 8- and 10-ft post spacings used, but this could be minimized by running a horizontal cable along the top of the material. The manufacturer has advised that the product is no longer produced.

A permanent type of snow fence constructed of perforated elements similar to pierced steel planking was also tested in North Dakota (Fig. 19). It had a high collection efficiency, comparable to the polyethylene waffle-weave fencing.

The principles of snowdrift control are set forth in detail in CRREL Cold Regions Science and Engineering Monograph III-A3c, *Blowing snow*.

Table IV. Snow fence materials.

Name	Type (or color)	Material	Manufacturer	Weave	Width (in.)	Wt (lb/ft^2)	Cost (¢/ft^2)	Remarks
a. Materials tested in the laboratory and in the field.								
Sisalkraft®	Orange label	Paper-glass reinforced	St. Regis	Solid	12	.011	1.7	
Sisalkraft®	Moistop®	Paper-polyethylene coated glass reinforced	St. Regis	Solid	12	.015	3.0	
Vexar®*	Black	Polyethylene	duPont	Large open	48	.175	11.2	
Shade	Green-PDJ60289	Rayon	Chicopee		48	.012		
Shade	Black-PDJ60421	Polypropylene	Chicopee		12, 48	.0067		
Shade	Orange-PDJ60471	Nylon	Chicopee		12, 48	.014		
Shade	Yellow-57045	PVC-coated nylon	Burlington		11, 45	.0067		
b. Materials tested in the laboratory only.								
Textilur®	Light green	PVC-coated nylon	Twitchell	Close		.026		High stretch
Lenonet®	Green	Polypropylene	Bemis	Close (6 X 6 in.)		.0173		Extreme sag
#84 bidirectional strapping tape	White	PVC-coated glass fiber	Butler	Solid		.0064		High sag
Hovotex® 10DN4050VT	Brown	Plastic-impregnated paper	Hollingsworth & Vose	Solid		.0061		Easily ripped

* No longer manufactured.

LIST OF MANUFACTURERS

Bemis Co.
Visinet Mill
P.O. Box 12224, Soulard Station
St. Louis, Missouri 63157

Chicopee Manufacturing Company
New Brunswick, New Jersey 08903

Hollingsworth & Vose Co.
East Walpole, Massachusetts 02032

Burlington Industrial Fabrics Co.
P.O. Box 21986
Greensboro, North Carolina 27406

E.I. duPont de Nemours Co.
Specialty Markets Division
Film Department
Wilmington, Delaware 19898

St. Regis Paper Co.
Laminated & Coated Products Division
Attleboro, Massachusetts 02703

Butler Paper Co.
Industrial Paper Division
Port Edwards, Wisconsin 54479

Twitchell Corp.
P.O. Box 1566
Dothan, Alabama 36301

Figure 17. Polyethylene waffle-weave snow fence (Vexar).

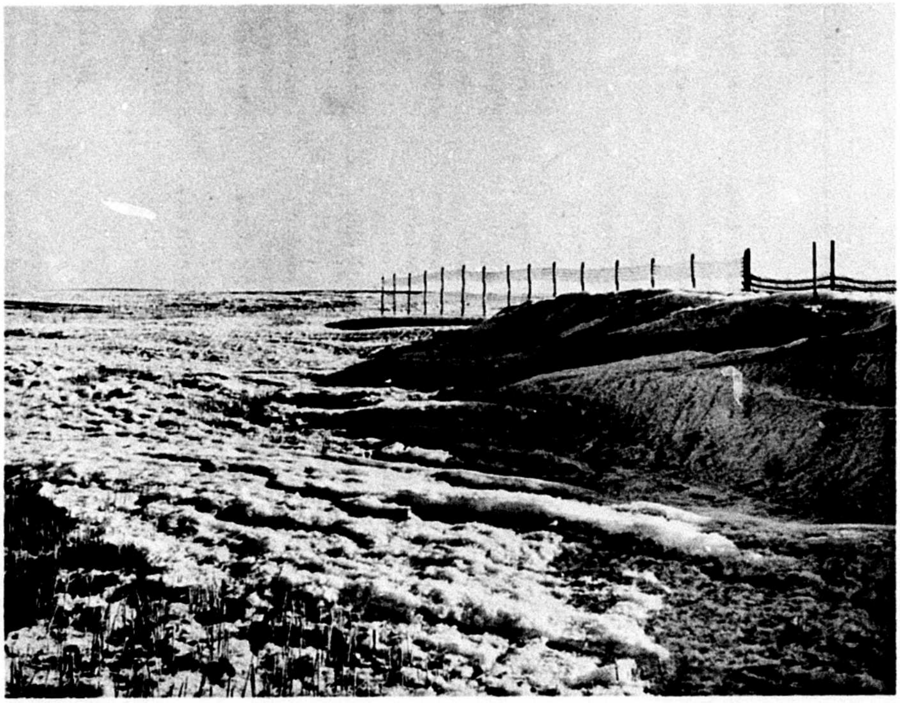

Figure 18. Deep accumulation at right is behind polyethylene waffle-weave fence (Vexar); lighter accumulation behind fence to the left resulted from the more open plastic shade material.

Table V. Potential solutions to Safeguard snow and ice accumulation problems.

Problem area	*Solutions*	*Objections*	*Developmental requirements*	*Capital cost**	*Use time per unit*
		SPRINT			
Recessed W/S tie-downs. Sprint tie-downs, recessed in the missile field pavement, will initially fill with snow which will ultimately harden or become ice. The frequency of use will determine preventive measure applicable.	a. Coat pavement and tie-down with anti-adhesion coating such as Teflon, then remove snow and ice using a combination of mechanical fracturing and cleaning out with compressed air.	Surface coating will gradually erode. Requires source of compressed air.	None	None†	1 min
	b. Fill recess with a high-viscosity hydrophobic grease such as silicone.	Grease may be spread onto pavement, resulting in slippery condition.	Selection of appropriate commercial material.	None	0
	c. Melt accumulation with torch (open-flame), hot-air gun (electric or fuel-fired) or infra-red.	Slow speed and possible damage to pavement.	Selection of appropriate commercial equipment.	$ 250	5 min
	d. Install flexible cap or plug.	May freeze in place or leak.	Design, selection of low temperature plastic.	1,500	1 min
Cover. Snow may accumulate on cover and around silo ring protruding above grade. Cover is soft plastic and may be damaged by mechanical contact.	a. Install electrically conductive sheet on surface; heat cables around periphery of protruding ring.	High power requirements, necessity to drain melt-water before it refreezes.	Selection of appropriate commercial heating sheet and heat cables.	36,000	
	b. Use hot-air blast to melt and dislodge accumulation.	Slow removal time; heated drainage necessary.	Commercial hot-air sources (e.g. gas turbines) or development of unit.	2,000	10 min
		SPARTAN			
Cover. Snow may accumulate on top of cover and in opening path and must be moved prior to maintenance.	a. Electrically heat surface with resistive sheet; heat cables around fixed base.	High power requirements, necessity to drain melt-water before it refreezes.	Methods of applying heating mat and feeding power to it because of irregular shape.	207,000	

	b. Mechanically disaggregate and displace with power rotary broom.	Not effective for wet bonded snow or ice; will not effectively remove snow from around cylinder or irregularities; difficult to maneuver around covers.	Modification of commercial powered brooms for operation over irregular cover surface.	20,000	10 min
	c. Dislodge snow with compressed air jet.	May not be an effective ice removal method (use of deformable covering may solve this); possible high power consumption.	Optimum design, capacity, and power requirements.	100,000	5 min
	d. Prevent snow and ice from accumulating on cover by use of foam dome or inflatable air bags, aerodynamically shaped.	Very effective in preventing accumulation of blowing snow, but snow and ice falling under calm conditions will still accumulate and will require removal.	Selection of appropriate plastic foam and design segmented disassembly; fabrication of air bags to the required configuration.	150,000	
	e. Hand shovel and sweep.	Slow, possibility of damage to cover.	None.	100	30 min
	f. Form air curtain around cell.	Unproved technique, possible high power consumption.	Optimum design and power requirements.		
		SPARTAN AND SPRINT			
Missile fields. Snow will accumulate between cells naturally or may be displaced there during cell cover clearing work and must be removed.	a. Mechanically remove with blade and rotary plows.	Heavy equipment in vicinity of cells poses hazard to cell covers.	(1) Guidance system to delineate safe clearance passage. (2) Selection and testing of commercial blade and rotary plows.	3,250 (325 markers)	
	b. Heat surface.	High power requirements; needs heated drainage system.	Selection of heating method and testing of large system.	1,200,000 (surface only)	

* Based on 30 Spartan, 68 Sprint covers, except 16 covers for heated surface method.

† Assumes that air compressor will be in TOE.

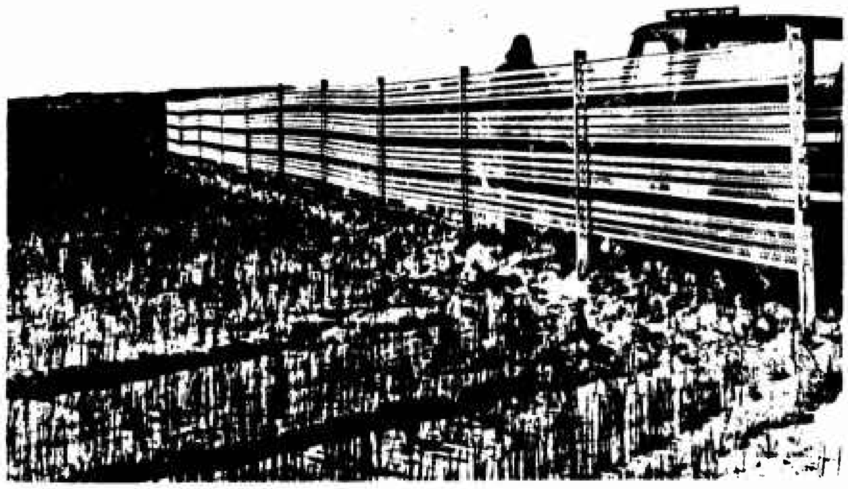

Figure 19. Perforated metal panels for constructing permanent snow fence.

Other methods

Snow fences could not be expected to prevent all accumulation on the missile covers, and therefore other methods were considered. A summary of problem areas and possible solutions is given in Table V.

4. SNOW REMOVAL

Methods and requirements

Cell covers can be cleared by heating the surface, or by shoveling and sweeping. The missile field can be cleared by heating the surface, and also by plowing with blade or rotary plows. In addition, a concept for non-contact removal of snow from cell covers, which would also be adaptable to field clearance—the eductor—was investigated (see below). Mechanical removal of snow requires its disposal, and methods include loading the snow into trucks and hauling it to a disposal site, using melting pits and pumping the melt to disposal areas, and casting the snow by rotary plow to an adjacent disposal area. Tests were conducted in winter 1967-68 on a heated Sprint cell cover at CRREL (Crory and Teeter 1968).

The high thermal requirements for complete melting of all accumulation on the missile field as the snow falls by means of heating devices built into the pavement (184,000 Btu/ft^2 for melting, 600,000 Btu/ft^2 for idling, for an entire season) make mechanical removal the most cost-effective method. The areas having a potential need for snow clearance at the Grand Forks Site are (in square feet):

	Cell covers	*Missile field*	*Total*
Spartan (30)	20,725 (37 X 18.7)	192,810	213,535
Sprint (16)	3,600 (15 X 15)	46,295	49,895
		239,105	263,430

Design snow clearance for 250,000 ft^2 of field covered with 1 ft of 0.2 g/cm^3 density snow, or 1560 tons, which would compact to 167,000 ft^3 (6185 yd^3) would require the following times and costs for two disposal methods:

Truck hauling	*Melting*
$\frac{6185}{10}$ = 618 loads	2 units, 320 yd^3/hr = 19 hr
8 trucks @ 4 loads/hr = 19 hr	
Operating cost @ \$10/hr/truck = \$1520	Operating cost @ \$30/hr = \$570
Capital cost @ \$10,000 = \$80,00	Capital cost @ \$20,000 = \$40,000

Estimate of time to clear the missile field:

Blade plowing of lanes @ 5 mph		3 hr
Cover cleaning (one cell)		2
Clean-up with small blowers		4
	Total	9 hr

An estimate of the frequency and volume of snow removal required for the various parts of the Safeguard complex is given in Appendix C. This estimate is based on a study of the contour drawings and an on-site evaluation.

Off-the-shelf commercial equipment can be used to clear the paved areas of the missile field, and commercial or modified equipment to clean dry snow off the cell covers. Bulk snow can be handled by truck-mounted blade plows and front-end loaders. The windrowed snow can be loaded into trucks by the rotary plow and/or front-end loaders, and clean-up around the covers is the job of small pedestrian-type snowblowers. Low density snow can be cleaned off the covers by use of compressed air jets, which may be mounted in the compressor truck or, for close-in and spot clean-up, may be in the form of an air lance at the end of a hose. Compacted snow or ice on the cover is more difficult to remove, and will require development of a satisfactory technique. Much of the required equipment is also suitable for base snow removal, thereby providing redundancy for the more essential missile field clearance. A small snowblower and front-end loader can clear around the Sprint covers at the RSL sites; a tilt-bed trailer should be used to transport the loader.

Two pieces of equipment were obtained for field trial at Nekoma during winter 1972-73: a rotary plow mounted on a front-end loader (Fig. 20) and a blade plow mounted on a low-ground-pressure tracked vehicle (Fig. 21). The former was intended for missile field snow clearance, the latter for clearance on unsurfaced areas such as between the double security fence. However, the extremely light snowfall precluded any meaningful tests.

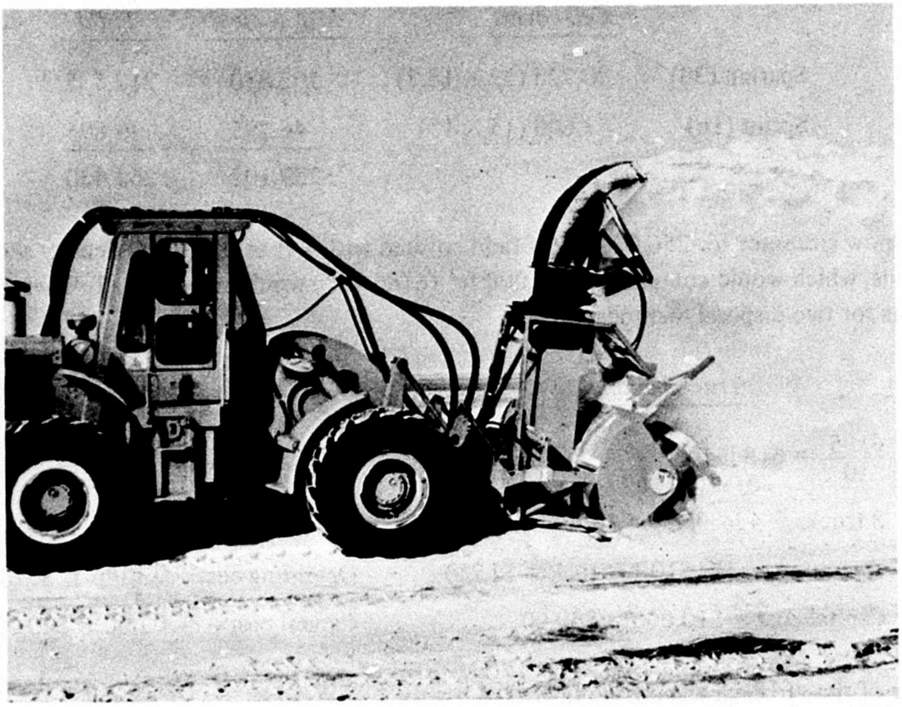

Figure 20. Rotary plow mounted on front-end loader; plow engine is hung on the rear of the loader. Hydraulic lines connect the hydraulic motor in rear with the plow hydrostatic drive.

Figure 21. Blade plow mounted on low ground pressure tracked vehicle, for clearance of snow on soft surfaces.

Table VI. Capital cost of equipment proposed for missile field snow removal.

Truck mounted 250-ft^3/min compressor ($7500 truck, $7000 compressor)	$ 14,500
Rotary plow on loader	60,000
Tilt-bed trailer (10-ton, 4-wheel)	5,000
Three front-end loaders, 2½ yd^3 articulated @ $19,000	57,000
Four 5-ton dump trucks w/front reversible blades (2 w/underbody blades) ($7500/truck, $1500/front blade; $2500/underbody blade)	41,000
Two 8-hp snowblowers @ $450	900
One pickup truck	2,100
Air attachments	2,000
	$181,500

The cost of the equipment suggested for removal of snow from missile fields and cell covers is given in Table VI. The concept will require five men for missile field clearance and three men for base clearance to man equipment at any one time.

Snowblower tests

It is undesirable to operate heavy equipment very close to the missile cells because of the potential for damage. Small, self-propelled, walk-behind snowblowers can be used for this purpose. One task in the CRREL investigation was to test representative snowblowers from the panoply of nearly 200 models produced by 30 manufacturers to establish the most important characteristics required for missile field applications. Characteristics that were considered important operating criteria were:

1. Cutter/impeller design
2. Cutter/impeller speed ratio
3. Cutting width/engine power
4. Wheel drive system
5. Wheel size and tire tread design
6. Operating controls.

Twelve machines were selected which incorporated these characteristics in various combinations and allowed comparisons of single characteristics. Only 7- and 8-hp units were included in the investigation because of the need for equipment to remove large quantities of fairly deep snow, a job exceeding the capabilities of small 3-5 hp home-type machines.

A report of the test procedure, physical characteristics of the machines tested, and test results was prepared (Hanamoto 1974). Only a brief discussion of the test and the conclusions are included here.

Snowblowers are small versions of highway-type rotary snowplows. They consist of a disaggregating device (cutter) and a throwing or casting device (impeller). Machines in which these are separate elements are two-stage machines; those in which the two functions are accomplished with one element are single-stage machines. Types of cutters are helical, open helical or ribbon, and drum. Impellers are either paddles or scoops rotating on an axis parallel to the cutter axis or at 90° to it.

Table VII. Snowblower characteristics.

a. Specifications.

Machine	Weight (lb) Front	Rear	Total	Speed (ft/sec) High	Low	Push-down force (lb)	Impeller speed (rpm)	Cutter Diam. (in.)	Width (in.)	Speed (rpm)	Ratio imp./cut.	Cut.-imp. rotation planes	Cast dist. (ft) R	L	Drawbar pull (lb)	with chains	Tire Tread	Diam.
Yardman 7200	63	198	261	3.8	1.0	53	1160	18	30	58	[redacted]	90°	31	24	99	154	Lugged Tractor	13
John Deere 832	62	194	265	3.9	2.3	33	1092	16	32	104	10.5	90°	28	20	88	171	Small Diamond	[redacted]
John Deere 726	57	181	238	3.8	1.2	35	1196	16	26	114	10.5	90°	-	-	82	[redacted]	Small Diamond	[redacted]
Allis Chalmers Tracker 8	78	193	271	3.1	0.8	72	1070	16	28	99	10.8	90°	-	-	75	148	Small Diamond	14
Bolens 832	67	210	277	4.1	2.2	37	1240	16	32	124	10.0	90°	45	27	81	121	Small Diamond	13
Gilson Uni-Trac 55016	46	202	248	3.5	2.0	25	1150	14	26	121	9.5	90°	33	24	93	129	Lugged Tractor	12.5
Ariens 910008	47	177	224	3.9	1.5	22	1030	16	24	100	10.3	90°	33	25	66	[redacted]	Small Diamond	12
Sears 536-90510 HC2	52	181	233	4.2	1.6	29	1190	15	24	119	10.0	90°	28	22	65	141	Small Diamond	12
Toro ,26	56	223	279	2.8	1.2	32	1016	16	26	112	9.0	90°	28	24	[redacted]	163	Lugged Military	12.5
Eska 952-A	78	143	221	2.2	2.2	40	688	14	26	688	1	Same	25	25	62	117	Small Diamond	12
Simplicity Sno-Away 7	75	197	272	2.2	1.7	52	910	12	26	146	6.2	Same	17	18	95	120	Lugged Tractor	11.5
Bobcat 1824A	46	206	253	2.9	1.7	38	1450	13	24	93	15.6	Same	37	37	67	128	Small Diamond	12

Stippled values are maximums measured

b. Performance.

Machine	Lane: Late snow, Removal rate (lb/min)	Lane: Late snow, Speed (ft/min)	Lane: Early snow, Removal rate (lb/min)	Lane: Early snow, Speed (ft/min)	Lane: New snow, Removal rate (lb/min)	Lane: New snow, Speed (ft/min)	Obstacle: Removal rate (lb/min)	Obstacle: Time (min)	Drift: Removal rate (lb/min)	Drift: Time (min)	Drift: Cutting height (in.)
Yardman 7200	[illegible]	15.4	[illegible]	41.8	1622	106.2	232	11.95	244	3.50	38
John Deere 832	1223	12.9	1374	32.8	1600	111.0	337	8.22	243	3.03	37
John Deere 726	1173	16.7	1384	40.7	-	-	-	-	[illegible]	2.63	37
Allis Chalmers Tracker 8	1062	13.7	1366	36.8	-	-	-	-	242	3.14	35
Bolens 832	952	10.4	1323	31.5	1447	84.0	337	8.22	274	4.39	39
Gilson Uni-Trac 55016	835	11.9	1592	46.2	[illegible]	115.4	[illegible]	6.93	184	2.82	36
Ariens 910008	834	11.9	1481	47.0	1137	81.0	264	10.48	145	3.93	31
Sears 536-90510 HC2	568	7.5	1151	36.5	1557	129.0	208	13.32	181	3.61	34
Toro .26	439	6.9	1398	40.2	1252	124.9	274	10.13	147	4.67	37
Eska 952-A	385	8.4	1565	45.8	1158	114.0	197	14.10	132	3.38	33
Simplicity Sno-Away 7	296	5.3	817	24.2	1151	104.1	194	14.28	108	5.03	30
Bobcat 1824A	267	5.5	860	27.3	876	64.2	174	15.95	146	4.13	35

Stippled values are maximums measured

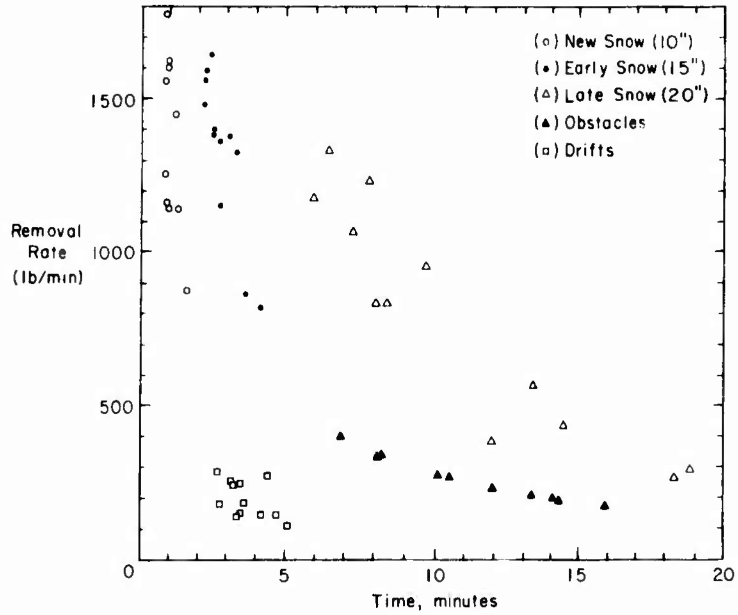

Figure 22. Snow removal rates of snowblowers tested in various types of snow. (From Hanamoto 1974.)

The machines' performance in three snow removal tasks – lane clearing, removal around obstacles, and drift removal – was evaluated. Each of these tasks requires different machine attributes, and the evaluation served to categorize the equipment capabilities and to indicate the machine or machines which could best meet the requirements. Tests were conducted in 10 to 20-in.-deep snow at CRREL and near Mt. Washington; snow densities ranged from 0.10-0.38 g/cm^3. Evaluation was made in terms of snow removal rate (lb/min). Performance in the three tasks, including three ages of snow in the lane clearing tests, varied widely, as is evident from the distribution of data points in Figure 22. Data points cluster only in the case of drift removal, probably because of the relatively low proportion of time spent actually cutting snow compared to the backing and elevating maneuvers.

Table VII summarizes significant machine characteristics and performance data. Top performance rates and desirable machine characteristics are stippled. Safety features, operating control convenience, and operator comments were incorporated in the evaluation but do not appear in this table.

The top performing machines were the Yardman, the two John Deere models, and the Gilson. The John Deere 726 is considered the best machine for handling all the varied tasks, and was the one preferred by operators when any snow clearance was required prior to a test run.

The tests have provided the data for establishing selection rules for future equipment, applicable to 7-8 hp models:

1. 26-in. cutting width
2. Large diameter (18 in. or greater) cutter
3. Ribbon-type double-lead helical cutter
4. Low cutter speed, 1 rev/sec
5. High impeller/cutter speed ratio, 20:1 or higher

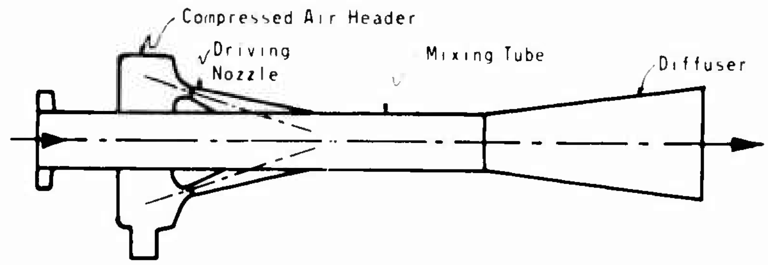

Figure 23. Schematic of eductor.

6. Disk-type impeller with rotation axis 90° to cutter
7. Push-down force on handles to lift nose not to exceed 25 lb
8. Large diameter tires (16 in. or greater) with tractor-type lugs
9. Wheel drive by disk and friction wheel.

Evaluation of the eductor concept

Introduction. It is difficult or impossible to remove snow from irregular surfaces with conventional mechanical snow removal devices such as blades, rotary plows, and power brooms. A high velocity air jet or fan can clear loose snow off a surface, displacing the material in a cloud to be deposited elsewhere locally. A more desirable method would be to dislodge accumulated snow from the surface, pick it up and conduct it to a nearby off-site storage area, a windrow, or to a truck for loading and hauling to a disposal area. Previous attempts to accomplish a similar task – the cutting of a trench or tunnel in the Greenland Ice Cap, carrying the snow cuttings in a closed duct to the surface for disposal – were only partially successful (Russell 1963). In this application, axial vane fans propelled the fine snow cuttings, but the high specific surface of the particles resulted in their rapid agglomeration, and accumulation on the fan blades was great enough to impede operation.

The removal of frozen ground and gravel cuttings from a borehole in Alaska was another similar problem faced by CRREL. Placing any momentum-imparting device in the duct itself was undesirable. Therefore an eductor was designed and successfully used to lift gravel up a 4-in.-ID suction pipe using up to 1200 ft^3/min (Lange 1973).

The eductor consists of three parts: an entrance where a primary stream (compressed air) and a secondary stream (snow) are accelerated before mixing, the mixing length where the primary stream accelerates the secondary stream, and a diffuser to decelerate the mixed stream and increase its pressure. Physically, the eductor is a 4-in. pipe with three nozzles placed equidistant around its axis, each at a 20° angle to the axis (Fig. 23).

Test of 4-in. eductor. The 4-in. eductor was brought from Alaska to CRREL in late 1971 and placed on a temporary stand in an outdoor test area. A Worthington air compressor, model 2016, delivering 600 ft^3/min at 100 psi, was obtained on loan from Tobyhanna Army Depot and connected to the eductor. Initial tests utilized the heavy 4-in. rubber pressure hose from the Alaskan drill work as the intake duct, admittedly a very unwieldy method. The qualitative tests run 26-28 January 1972 with this set-up transporting disaggregated hard snow or loose dry snow were successful, however. Snow was cast a considerable distance: frozen chunks of snow up to 1 in. in

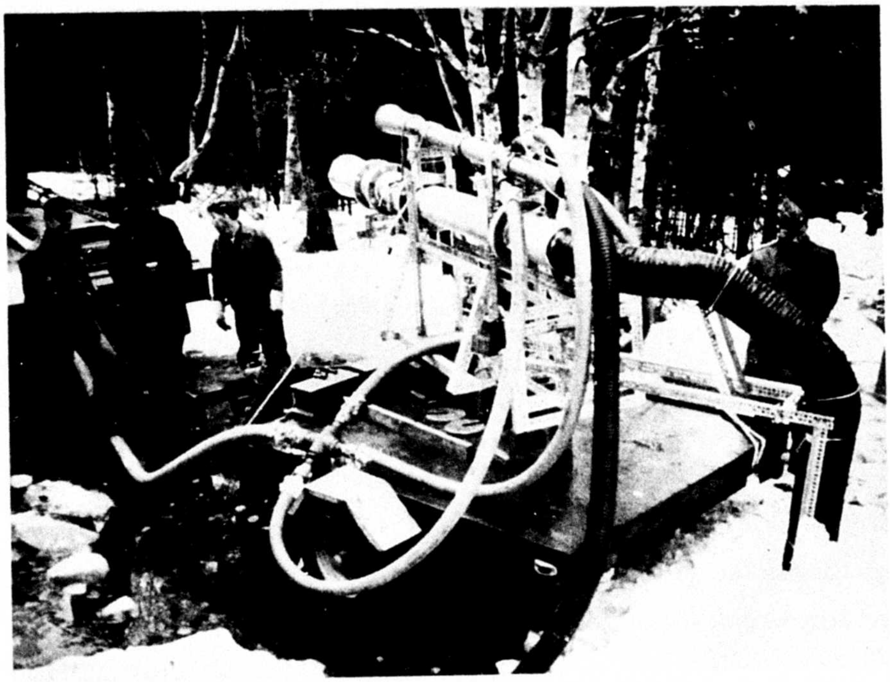

Figure 24. Four-inch mixing tube eductor (top) and 8-in. eductor on trailer at Mt. Washington approach road test site on 4 May 1972. Flexible intake ducts at right. A single 3-in. compressed air line from the compressor was split into three 2-in. lines to feed the eductor nozzles.

diameter were cast up to 100 ft from the exhaust, and fine material from 6½-44 ft. Temperature during the entire test period was near 18°F. Two production runs with dry, loose snow gave a rate of about 16 ft^3/min. The eductor was not volume-limited, though; much time was lost in maneuvering the heavy, unwieldy hose through the snow collected in a 7.4-ft^3 box. All snow passing the intake was discharged cleanly. Lumps of frozen snow larger than the intake plugged it and were not drawn in.

Design and test of 8-in. eductor. In the anticipated application, less cast distance and higher volumetric capacity were considered desirable. This could be achieved by using the same volume of compressed air exhausting into a larger duct, though mixing efficiency of the two streams might not be optimum. The primary design criterion was to transport all the snow ingested, with none dropping out in the duct. Snow up to a size of a few millimeters has a terminal fall velocity of 3 ft/sec; a flow speed of ten times this value, 30 ft/sec or 1800 ft/min, was chosen for design. An 8-in.-diameter duct 8½ ft long from the intake coupling to the end of the diffuser section met this requirement. Heavy-wall aluminum pipe was used to fabricate the constant diameter mixing tube section, and heavy steel sheet was rolled to form the diffuser. Nozzles were duplicated from the 4-in. design. Flexible duct was attached to the intake and supported by a counterweighted slotted steel angle frame. Since the air speed at intake was not designed to pick up crusted or consolidated snow, two methods of disaggregating a snow cover were designed, tested in the lab, and attached to the intake frame. Both methods utilized air as the power source for commonality. One method used six air jets angled down and towards the center of the intake, the other used six air cylinders forcing wedges into the snow over a 1-in. travel. Both air jets and wedges were operated sequentially by means of a timer-stepping switch and solenoid valves.

Field test. The 8-in. eductor was given its first snow test during a demonstration on the Mt. Washington cog railway access road on 4 May 1972 (Fig. 24). Snow had not been cleared from this road all winter, and 3-4 ft of wet, well-bonded granular snow remained. The trailer carrying the eductors was backed into the snow area to give convenient access for the intake ducts. The hard, aged snow was not broken by the air jets, nor was the air pressure high enough to force the wedges into the snow. Therefore, it was necessary to break up the snow with a shovel, or scoop it up with the edge of the intake, to feed it into the eductor. At no time was snow added faster than the eductor could discharge it. Cast distance was within the design goal of 25-40 ft. The test was not conclusive, however, since the compressor could not maintain the full 100 psi pressure for the rated 600 ft^3/min; pressure did not exceed 75 psi. No further tests were carried out.

CONCLUSIONS

1. Accumulation on the missile covers will not exceed 1 in. of ice and 20 in. of snow during one storm if obstacles are prevented from interfering with complete wind scouring of the missile field.

2. Maximum snow load for the case stated in 1. above is 40 lb/ft^2.

3. Snow will accumulate between and on each side of the double security fence to a depth up to 30 in. every year, and to depths approaching 5-6 ft in extreme conditions (based on Grand Forks Minuteman experience).

4. Snow will accumulate around the base of each missile cover up to the sloping surfaces and will become very hard and dense with age. It will not bond tightly to the missile cover, however.

5. A snow fence material which is non-debris-forming, durable, and very effective in accumulating snow was found in field evaluation of a number of materials.

6. The climate in the vicinity of Nekoma, North Dakota, is very similar to that at Minot and Grand Forks, the closest first order weather stations with at least 10 years of record.

7. From 25-40 snowstorms can be expected each winter, many lasting more than 12 hours. Depth of snow falling during a single storm can be expected to reach 11 in. each year, and 20 in. 1 year in 30.

8. Snow can be cleared from cell covers by mechanical means rather than by an eductor.

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APPENDIX A. SNOW DEPTHS ON SIMULATED SPARTAN MISSILE FIELD, NOVEMBER 1971-APRIL 1972

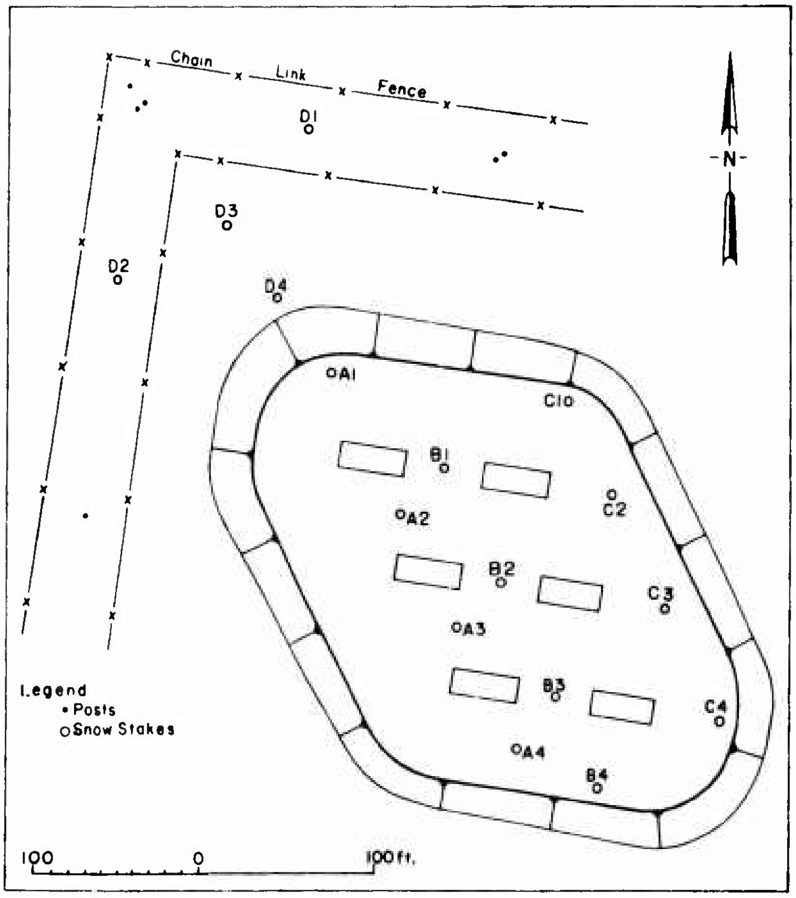

Figure A1. Full-scale model of Spartan missile field showing location of snow measurement stakes.

Snow Depth Readings of Stakes A-1 to E-3 (in.)

Nov.	A-1	A-2	A-3	A-4	B-1	B-2	B-3	B-4	C-1	C-2	C-3	C-4	D-1	D-2	D-3	D-4	E-1	E-2	E-3
16	1.5	2.5	2.5	2.5	2.5	2.5	2.5	1.5	2.5	2.0	2.0	1.5	2.5	1.0	2.0	1.5	1.5	1.5	2.0
17	.5	0	0	0	1	.5	.5	0	.5	.5	.5	0	0	1.5	1	1.5	0	1.5	1
18	0	0	0	0	0	.5	0	0	0	0	0	0	2	0	2	0	3	3	0
19	0	0	.5	0	0	0	0	0	0	0	0	0	.5	.5	0	1.5	1.5	1.5	0
20	0	.5	.5	0	0	0	0	0	0	0	0	0	.5	.5	0	1.5	1.5	1.5	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.5	0	1.5	1.5	0
22	0	0	0	0	0	0	0	0	0	0	0	0	.5	0	1	0	1	.5	0
23	0	0	0	0	0	0	0	0	0	0	0	0	.5	0	.5	0	1	1	0
24	0	0	0	0	0	0	0	0	0	0	0	0	.5	0	.5	0	1	1	0
25	0	0	0	0	0	0	0	0	0	0	0	0	.5	0	.5	0	1	1	0
26	0	0	0	0	0	0	0	0	0	0	0	0	.5	0	.5	0	1	1	0
27	T	T	T	T	T	T	T	T	T	T	T	T	.5	T	.5	T	1	1	T
28	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1	1	1	1	2	2	1.5
29	1	1	.5	.5	1	1	.5	.5	1	1	.5	.5	1.5	1.5	1.5	2	2	2	1.5
30	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2	2	1.5	1	2.5	2.5	1
Dec.																			
1	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2	2	2.5	2	2	2.5	1.5
2	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2	2	2.5	2	2	2.5	1.5
3	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1.5	1.5	1.5	1.5	1.5	1
4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1.5	1.5	1.5	2	2	1.5
5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1.5	2	2	4	3.5	1.5
6	.75	.75	1	.5	.75	.75	1	.5	.75	.75	1	.5	2	2	2	2	4	3.5	1.5
7	.75	.75	1	.5	.75	.75	1	.5	.75	.75	1	.5	2	2	2	2	4	3.5	1.5
8	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1.5	1.5	1.5	4	3.5	1.5
9	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1	1	1	1	4	3.5	1.5
10	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	1	1	1	1	4	3	1
11	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	1	1	1	1	4	3	1
12	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3.5	2.5	0
13	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3.5	2.5	0
14	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3.5	1.5	1	1.5	5	4	5
15	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	1	1	1	5	5	T
16	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2.5	2.5	2.5	2.5	5	5	.5
17	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	5	5	.5
18	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	5	5	T
19	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	5	5	0
20	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2	5	5	T
21	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	5	5	T
22	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1	3.5	5.5	5.5	T
23	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1	2.5	5	5	T
24	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1	2.5	5	5	T
25	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1	2.5	5	5	T
26	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	2.5	1	2.5	5.5	5.5	.5
27	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	2	1	3	5.5	5.5	.5
28	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1	2.5	1.5	3	5.5	5.5	.5
29	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	1	3	5	5	.5
30	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	1	3	5	5	.5
31	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3	1	3	5	5	.5
Jan.																			
1	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1.5	1	3	6.5	6	.5
2	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	1.5	1.5	1	3	6.5	6	T
3	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2.5	2	2	3.5	8	6.5	.5
4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2.5	2.5	2	3	8	6	.5
5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2.5	2.5	2.5	3	8	7	.5
6	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	2.5	8	7.5	.5
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11	.5	1	1	.5	3	1	4	.5	.5	T	T	.5	3.5	2	5	5	8	7	1
12	.5	1	1	1	2	.5	2	.5	1	T	T	T	2	3	2	3	8	7	1
13	.5	1	1	.5	2.5	.5	1	1	1	T	T	T	1.5	2	3.5	4	8.5	8	1.5
14	.5	.5	.5	.5	1	1	.5	.5	.5	T	T	T	2	3.5	3	4	7.5	7	T
15	T	1	1	T	2	1	2	T	T	T	T	T	2	4	2	3	7	7	T
16	.5	.5	T	T	T	.5	T	.5	T	T	T	.5	1	3	2	5	6	7	0
17	.5	.5	T	T	.5	T	1	.5	T	T	T	T	2	3	2	5	8	6	.5
18	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	7	7	0

Note: Stakes E-1, E-2, E-3 were located upwind of met van.

Snow Depth Readings of Stakes A-1 to E-3 (in.)

Jan. Con't	A-1	A-2	A-3	A-4	B-1	B-2	B-3	B-4	C-1	C-2	C-3	C-4	D-1	D-2	D-3	D-4	E-1	E-2	E-3
19	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	7	6	0
20	0	0	0	0	0	0	0	0	0	0	0	0	5	2	2	4	7	7	T
21	0	T	0	0	T	0	0	0	T	0	0	0	2	2.5	3	4.5	6	8	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	6	8	0
23	2	2	2	2	2	2	2	2	2	2	2	2	2	3.5	2	13	7	9	2
24	0	0	0	0	0	0	0	0	0	0	0	0	3	3	6	14	9	9	T
25	0	0	0	0	0	0	0	0	0	0	0	0	2	1	4	12	9	8	T
26	0	0	0	0	0	0	0	0	0	0	0	0	2	1	4	12	9	8	T
27	0	0	0	0	0	0	0	0	0	0	0	0	2	T	3	12	9	8	T
28	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	13	9	8	T
29	0	0	0	0	0	0	0	0	0	0	0	0	2	T	3	13	9	9	0
30	T	T	T	T	T	T	T	T	T	T	T	T	2	.5	3	13	9	9	0
31	1	1	1	1	1	1	1	1	1	1	1	1	3	4	4	13	9	9	1
Feb.																			
1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	13	9	9	1
2	1	1	1	1	1	1	1	1	1	1	1	1	2	2.5	3	13	9	9	1
3	.5	0	0	0	.5	0	0	0	.5	0	0	0	1.5	3	3	12	9	9	T
4	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	12	9	9	0
5	T	T	T	T	T	T	T	T	T	T	T	T	1.0	3	3	13	9	9	T
6	T	T	T	T	T	T	T	T	T	T	T	T	1	3	3	13	9	9	.5
7	T	T	T	T	T	T	T	T	T	T	T	T	2	3	3	13	8	9	T
8	T	T	T	T	T	T	T	T	T	T	T	T	3	3	3	13	8	8	1
9	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	13	9	8	T
10	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	13	9	9	0
11	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	12	9	9	0
12	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	12	9	8	0
13	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	12	9	9	0
14	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	11	7	8	0
15	T	T	T	T	T	T	T	T	T	T	T	T	1	2	3	12	8	7	0
16	T	T	T	T	T	T	T	T	T	T	T	T	1.5	2.5	3	13	9	8	T
17	T	T	1.5	T	T	T	1	T	T	T	T	T	2	2	5	12	9	9	2
18	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	13	10	10	1
19	0	0	0	0	0	0	0	0	0	0	0	0	2	4	9	12	9	9	0
20	0	0	0	0	0	0	0	0	0	0	0	0	2	4	9	12	9	9	0
21	0	0	0	0	0	0	0	0	0	0	0	0	2	4	9	12	9	9	0
22	0	0	0	0	0	0	0	0	0	0	0	0	2	4	9	12	10	10	0
23	0	0	0	0	0	0	0	0	0	0	0	0	12	6	18	18	10	10	1
24	T	T	T	T	T	T	T	T	T	T	T	T	10	6	15	18	10	10	T
25	T	T	.5	T	T	T	T	T	T	T	T	T	10	7	18	16	12.5	12.5	T
26	.5	1	1	.5	.5	.5	.5	.5	.5	.5	.5	.5	10	7	10	16	12	13	T
27	.5	0	.5	1	.5	.5	.5	.5	.5	.5	.5	.5	9	7	15	18	13	12	.5
28	0	1.5	.5	1.5	.4	0	.5	0	0	0	0	0	9	8	16	18	16	24	3
29	0	.5	1.5	2	3	1	2	1	3	1.5	1	1	9	9	15	18	17	18	2
March																			
1	0	0	0	0	0	0	0	0	0	0	0	0	8	8	12	14	13	13	4
2	0	0	0	0	0	0	0	0	0	0	0	0	7	7	17	17	13	13	3
3	0	0	0	0	0	0	0	0	0	0	0	0	5	9	20	18	13	18	6
4	0	0	0	0	0	0	0	0	0	0	0	0	7	9	19	19	17	21	4
5	0	0	0	0	0	0	0	0	0	0	0	0	7	9	20	19	17	21	5
6	0	0	0	0	1	5	2	0	0	0	0	0	13	7	15	18	13	18	1
7	0	0	0	0	1	5	1	0	0	0	0	0	14	6	11	15	13	18	6
8	0	0	0	0	.5	3	.5	0	0	0	0	0	12	6	13	15	12	18	4
9	0	0	0	0	.5	2	.5	0	0	0	0	0	24	7	12	15	12	18	2
10	0	0	0	0	0	2	0	0	0	0	0	0	24	7	12	15	12	18	1
11	0	0	0	0	0	2.5	0	0	0	0	0	0	23	7	11	13	12	16	0
12	0	0	0	0	0	1	0	0	0	0	0	0	19	6	9	13	11	15	0
13	0	0	0	0	0	1	0	0	0	0	0	0	17	5	7	8	7	14	0
14	0	0	0	0	0	0	0	0	0	0	0	0	13	2	5	6	5	12	0
15	0	0	0	0	0	0	0	0	0	0	0	0	8	2	5	2	3	7	0
16	0	0	0	0	0	0	0	0	0	0	0	0	6	1	0	3	0	4	0
17	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Snow Depth Readings of Stakes A-1 to E-3 (in.)

March Con't	A-1	A-2	A-3	A-4	B-1	B-2	B-3	B-4	C-1	C-2	C-3	C-4	D-1	D-2	D-3	D-4	E-1	E-2	E-3
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	1	0	1	0	0	0	0	0	0	0	0	2	1	1	6	9	0
28	0	2	.5	0	5	3	5	0	0	0	1	.5	4	6	6	6	12	12	4
29	0	2	.5	0	5	3	5	0	0	0	1	.5	4	6	6	6	12	12	4
30	0	2	.5	.5	5	3	5	0	0	0	1	.5	4	6	6	6	12	12	4
31	0	2	.5	.5	5	3	5	0	0	0	1	.5	4	5	5	5	11	11	4
April																			
1	0	2	.5	.5	5	3	5	0	0	0	1	.5	4	5	5	5	10	11	3
2	0	1.5	0	0	4	2.5	3.5	0	0	0	0	0	3	4	3.5	4	7	8	1
3	0	0	0	0	0	.5	0	0	0	0	0	0	3	2	2	1	5	5	0
4	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	1	3	3	0
5	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
6	0	0	0	0	0	0	0	0	0	0	0	0	1	1	.5	1	1	1	0
7	0	0	0	0	0	0	0	0	0	0	0	0	1	1	.5	1	1	1	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.5	1	1	1	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.5	1	1	1	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.5	1	1	1	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15																	0	0	0
16																	0	0	0
17																	3	3	3
18																	1	1	1
19																	0	0	0
20																	0	0	0
21																	0	0	0
22																	0	0	0
23																	T	T	T
24																	0	0	0
25																	0	0	0
26																	0	0	0
27																	0	0	0
28																	0	0	0
29																	0	0	0
30																	0	0	0

Stakes A,B,C,D, Terminated on 14 April 1972

Stakes A,B,C,D, are terminated on 14 April 1972

APPENDIX B. CLIMATOLOGICAL DATA

Table BI. Station: Nekoma, N.D.

Date 1971 November	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	32	12	22	.2	.8		R 6, S 6	S	4	-
2	32	23	28					WNW	10	23
3	28	23	26					NNW	11	29
4	37	18	28	.05			S 6	S	12	25
5	25	23	24		.1			NW	23	37
6	26	6	16					N	17	36
7	19	-5	7					SSW	7	21
8	33	-18	8					W	10	23
9	40	-19	10	.02			L-, R 6	WSW	4	-
10	39	23	31	.03			L-, R 12	WSW	3	-
11	42	26	34	T			L-, R 6	VAR.	3	-
12	37	30	34	.02			L-, R 6	SSE	7	-
13	34	29	32	T			L-, R 18	SSE	8	-
14	34	32	33	.02			L-, R 12	NE	5	-
15	36	32	34	.03			L-, R 6	NNW	7	-
16	33	27	30			1.5		E	4	-
17	30	28	29	.08	.1	1.5	S 12	NE	3	-
18	28	26	27	.03	.1	3	S 12	NNE	9	18
19	35	20	28	.05	.25	1.5	S 6	NW	10	23
20	26	26	26		.1	1.5		NNE	11	23
21	23	5	14	.02		1.5	S 6	SW	6	19
22	33	18	26	.01		.5	S 6	SSW	12	33
23	34	25	30	.03		1	S 6	NW	10	30
24	18	7	12		T	1		N	4	-
25	22	14	18		T	1		S	5	-
26	24	19	22			1		VAR.	3	-
27	18	18	18	.02	T	1	S 6	ESE	5	-
28	10	4	7	T	1	2	S 6	ESE	5	-
29	10	0	5	.02	.5	2	S 6	ESE	3	-
30	10	-7	2		T	2.5		S	3	-
Totals	42	-19	23	.63	2.95	3 max		NE+NW	8 ave	33 max

Date 1971 December	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	27	6	16		T	2.5		WSW	7	-
2	32	11	22	.01		2.5	L- 6	WSW	7	-
3	26	11	18			1.5		SSW	6	-
4	27	20	24	.1	2	2	S 18	SSW	5	-
5	21	20	20	.01	.5	3.5	S 6	W	3	-
6	22	15	18	.01		3.5	L- 6	NE	5	-
7	3	-3	0			3.5		NE	7	-
8	9	-7	1			3.5		W	3	-
9	22	-2	10			3.5		SSW	9	26
10	16	10	13			3		NW	10	28
11	2	-6	-2			3		NW	14	28
12	2	-10	-4			2.5		NNW	6	-
13	2	-12	-5	.01		2.5	S 6	SE	6	-
14	20	-2	9		1	4		S	8	20
15	20	19	20			5		N	8	20
16	-2	-9	-6			5		NNW	10	22
17	0	-20	-10			5		WSW	7	-
18	24	11	18			5		WNW	5	19
19	14	-8	3			5		W	5	-
20	22	10	16	.03	T	5	S 12	N	8	23
21	2	-12	-5		.4	5		SE	6	18
22	18	-3	8			5.5		SE	8	18
23	19	16	18	.06	T	5	S 24	NNE	9	23
24	-5	-17	-11			5		S	8	22
25	-2	-7	-4			5		N	7	19
26	-10	-18	-14		.5	5.5		W	6	-
27	15	-14	0			5.5		W	10	17
28	18	-7	6			5.5		WSW	7	18
29	14	-5	4			5		ESE	4	-
30	12	3	8			5		WSW	5	-
31	29	-2	14	.01		5	S 6	W	10	20
Totals	32	-20	7	.24	4.4	5.5		NW+SE	7 ave	28 max

Table BI (cont'd). Station: Nekoma, N.D.

Date 1972 January	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	22	14	18		1.5	6		W	10	18
2	15	11	13	.03		6	S 12	NNW	8	19
3	-6	-16	-11	.01	T	6.5	S 6	NW	6	18
4	1	-21	-10			6		SW	6	17
5	14	1	8			7		VAR.	8	25
6	28	-3	12	.03	1	7.5	S 12	VAR.	11	36
7	23	3	13			7		SW	5	-
8	33	20	26	.01	T	7	S 6	VAR.	10	32
9	7	-7	0	.05	T	8	S 1	VAR.	10	28'
10	10	-10	0		3	8.5		W	7	21
11	6	-16	-5			7		S	8	20
12	-9	-4	-6			7		N	11	22
13	-22	-21	-22		.5	8		NW	11	23
14	-28	-34	-17			7		WNW	11	24
15	-12	-37	-24			7		S	9	30
16	38	-13	12	.05	.5	7	S 6	SW	11	26
17	38	21	30			6		SSW	7	18
18	-1	-9	-5		T	7		NNW	12	23
19	-3	-16	-10	.02		6	S 6	VAR.	5	-
20	-11	-10	-10	.03	1	7	S 6	NNW	8	18
21	16	-16	0	.02	1	8	S 12	S	11	29
22	-5	-16	-10		.5	8		WNW	9	-
23	2	-6	-2		1	9		VAR.	4	-
24	-19	-16	-18	.05	.5	9	S 6	NNW	13	25
25	-21	-32	-26			8		WNW	12	26
26	-16	-31	-24			8		W	10	-
27	-12	-28	-20			8		WSW	10	17
28	-6	-23	-14			8		WSW	7	-
29	-7	-23	-15			9		NW	7	-
30	13	-19	-3			9		S	4	-
31	13	0	6	.02	.5	9	S 6	WNW	4	-
Totals	38	-37	-3	.32	11	9 max		NW	9 ave	36 max

Date 1972 February	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	5	-7	-1	.01	.5	9	S 6	NNW	5	-
2	1	-21	-10	.01	.2	9	S 6	SW	5	-
3	3	-15	-6		.1	9		NW	10	-
4	-7	-20	-14			9		WNW	7	-
5	-3	-14	-8		T	9		NE	4	-
6	-6	-23	-14			9		WNW	6	-
7	4	-27	-12			9		W	3	-
8	2	-21	-10			8		VAR.	4	-
9	5	-16	-6			8		SSE	4	-
10	11	-9	1			9		SSW	10	19
11	28	5	17			9		S	7	18
12	29	18	24			8		WNW	9	26
13	39	9	24			9		S	8	25
14	8	7	8			8		NNW	11	23
15	19	-5	7			7		SSW	4	-
16	21	5	13	.02	.5	8	S 6	ESE	10	23
17	18	9	14	.08	1.5	9	S 12	NNW	17	36
18	12	-8	2	.01	.5	10	S 6	NNW	6	-
19	16	0	8			9		ESE	10	21
20	25	9	17					S	9	17
21	5	-7	-1			9		NW	16	26
22	8	-11	-2	.05		10	S 6	SE	8	20
23	5	2	4	.1		10	S 12	N	13	26
24	8	-10	-1	.06	.8	10	S 12	SSW	3	-
25	5	-18	-6		.3	12.5		WNW	3	-
26	1	-7	-3	.06	.3	13	S 12	ENE	5	-
27	5	-8	-2	.05	.4	12	S 12	ENE	6	-
28	4	-7	-2	.03	2.4	24dr	S 12	NNE	8	-
29	4	-3	0	.15		18	S 18	NNE	10	29
Totals	39	-27	1	.63	7.5	13 (24 in. drifts)		WNW+SE	8 ave	36 max

Table BI (cont'd).

Date	Temperature(°F)			Precipitation(in.)				Wind (kt)		
1972 March	Max	Min	Ave	Precip	Snow Fall	Snow on Ground	Type + Hrs.	Dir.	Speed	Peak Gust
1	-5	-13	-9		2.8	13		NNE	9	19
2	0	-26	-13			13		SW	3	-
3	2	-5	-2	.05	.8	18	S 12	NE	12	23
4	-2	-19	-10	.03	.9	21dr	S 6	NNW	6	-
5	14	-9	2	.03		21dr	S 6	SW	5	17
6	38	-9	14	.06	.9	18	S 12	SSE	17	41
7	13	5	9		1.1	18		NW	19	36
8	17	-12	2		.6	18		NW	4	-
9	15	-11	2		T	18		NNW	4	-
10	36	3	20			18		S	10	30
11	28	17	22			16		NNE	5	-
12	35	16	26			15		SW	3	-
13	40	21	30			14		SSE	6	-
14	39	26	32	.14		12	L-, R 6	SSW	[illegible]	20
15	40	32	36	.01		7	L-, R 6	NW	7	20
16	45	32	38			4		NW	8	-
17	35	27	31		T	0		NE	5	-
18	41	31	36			0		S	5	-
19	37	32	34			0		ENE	5	-
20	39	32	36			0		SSW	5	17
21	30	28	29			0		NW	11	23
22	28	19	24			0		NNE	7	17
23	32	21	26			0		ESE	9	19
24	33	26	30			0		SE	9	19
25	34	27	30			0		ESE	7	-
26	31	26	28	.05		0	S 6	E	12	26
27	24	21	22	.23	2.3	9	S 24	E	14	24
28	26	19	22	.02	4.7	12	S 6	NW	9	17
29	27	10	18		.1	12		WNW	5	-
30	26	2	14			12		NNW	4	-
31	30	14	22			11		NNW	11	25
Totals	45	-26	19	.62	14.2	18 (21 in. drifts)		NW+SW	8 ave	41 max

Date	Temperature(°F)			Precipitation(in.)				Wind (kt)		
1972 April	Max	Min	Ave	Precip	Snow Fall	Snow on Ground	Type + Hrs.	Dir.	Speed	Peak Gust
1	35	12	24			11		N	4	-
2	36	20	28			8		S	10	22
3	19	10	14			5		WNW	14	30
4	26	3	14			3		WNW	11	30
5	31	9	20			1		ESE	7	-
6	29	21	25	.05		1	S 6	E	14	29
7	26	20	23	.03	.8	1	S 6	SE	12	22
8	40	23	32	.02	T	1	S 6	S	10	23
9	41	31	36			1		S	7	17
10	39	32	36			1		NW	8	24
11	34	27	30	.03		0	S 6	S	5	-
12	35	31	33	.04	T	0	L-, R 6	ESE	9	22
13	42	32	37			0		NNE	6	-
14	51	33	42			0		SSW	6	17
15	60	34	47			0		WSW	8	23
16	49	33	41			0		NW	10	27
17	37	30	34	.05	1.8	3	S 12	ENE	7	20
18	46	27	36			1		NNE	4	-
19	53	32	42			0		VAR.	3	-
20	54	32	43			0		S	5	-
21	50	38	44	.1		0	L-, R 6	ESE	5	17
22	43	32	38	.05		0	L-, R 12	NE	6	18
23	43	32	38	.2	T	T	L-, R 24	NNE	6	19
24	49	28	38	.01	T	0	S 6	E	2	-
25	54	31	42			0		S	11	26
26	56	38	47	.02		0	L-, R 6	SSW	8	19
27	60	42	51	.03		0	L-, R 6	S	3	-
28	62	35	48			0		SE	5	17
29	63	40	52			0		SSE	6	22
30	63	42	52			0		SE	7	19
Totals	63	3	36	.63	2.6	11 max		NW+SSE	7 ave	30 max

Table BII. Station: Grand Forks AFB, N.D.

Date 1971 November	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	35	20	28	.2	1.0	5	SW-5, S-2, F 4	W	3	8
2	37	30	34	.03	.8	5	IP 1, S-2, F 6	W	14	39
3	35	30	32	T	T	5	S-2	WNW	15	32
4	40	19	30	T	0	5	R 1	S	12	33
5	38	20	29	0	0	2	BS 3, DS 6	W	26	49
6	23	12	18	T	T	2	S-3, BS 3, DS 5	WNW	27	42
7	26	6	16	0	0	1		SSE	8	19
8	39	24	32	0	0	1		S	9	19
9	43	28	36	0	0	1		SW	8	19
10	40	25	32	0	0	1		SSE	4	14
11	46	30	38	0	0	1		W	3	16
12	39	25	32	0	0	1	F 10	NNW	2	8
13	42	26	34	0	0	T	F 8	E	4	13
14	36	33	34	.02	0	T	L-12, F 17	N	6	14
15	39	30	34	0	0	T	F 5	W	6	17
16	35	31	33	T	0	T	F 8	N	7	16
17	33	30	32	T	T	T	F 17, SW 1	N	11	20
18	33	29	31	.02	T	T	S-18, F 1	NNW	11	22
19	39	26	32	T	T	T	S-7, F 4, R 2	WNW	12	29
20	35	22	28	T	T	T	S-5, SW 1	N	14	37
21	25	18	22	T	T	T	S-2, SW 1	NNW	8	27
22	32	22	27	T	T	T	SW 1	S	18	36
23	38	26	32	T	T	0	SW 1	W	12	32
24	27	18	22	0	0	0		WNW	6	18
25	29	18	24	T	T	0	SW 3	E	5	14
26	28	24	26	T	T	0	SW 1	N	4	15
27	27	18	22	T	T	0	S-10, F 5, ZL 7	N	8	18
28	17	7	12	T	T	T	S-7, F 5, IC 2	N	6	15
29	17	6	12	T	T	T	S-2, IC, 1 F 8	N	6	11
30	17	5	11	T	T	T	IC + IF 8	N	2	7
Totals	46	5	27.5	.27	1.8	5 max		NW	10 ave	49 max

Date 1971 December	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	30	13	22	0	0	T		SSW	5	13
2	33	15	24	0	0	T	F 3	S	8	19
3	26	16	21	T	T	T	F 19, S-4	S	12	20
4	28	26	27	.01	T	T	F 24, ZR 1, S-19, ZL 1	SSE	13	25
5	30	20	25	0	0	T	F 4	SSE	7	18
6	25	19	22	.06	2	2	F 18, S-6	N	10	25
7	16	5	10	T	T	2	BS 18, F 8, S-12, DS 3	N	18	31
8	13	2	8	0	0	2		N	6	20
9	19	3	11	0	0	2	BS 3	S	12	25
10	26	12	19	0	0	2	BS 1	W	10	26
11	12	4	8	0	0	1		W	15	30
12	9	-2	4	0	0	1		WNW	6	20
13	13	-3	5	T	.6	2	IC 2, S-9	E	5	13
14	23	5	14	.04	.5	2	S-8, F 9	SSE	10	22
15	27	9	18	.06	1.0	2	F 13, S-5, ZL 2	NW	8	22
16	8	-8	0	T	T	3	S-1	WNW	11	23
17	3	-13	-5	0	0	3		S	6	12
18	26	4	15	T	T	3	S-3	S	7	20
19	18	2	10	.01	.2	3	S-2	S	7	19
20	28	4	16	T	.1	3	S-3, IC 1, BS 2	VAR.	8	26
21	8	0	4	0	0	3		NE	4	10
22	25	9	17	T	T	3	F 14, ZL 9, S-4	SE	6	14
23	26	6	16	T	T	3	F 17, S-2, ZL 16, BS 1	N	8	24
24	3	-9	-3	0	0	3		VAR.	8	22
25	5	-5	0	T	T	3	IC 11, ZL 1, S-7, BS 3	N	10	25
26	-6	-12	-9	T	T	3	S-3, IC 1	N	7	17
27	10	-7	2	T	T	3	S-3	W	7	14
28	24	-3	10	T	T	3	IC 3	SSW	8	23
29	17	1	9	T	T	3	S-1, F 1	ENE	3	10
30	21	4	12	.01	.3	3	S-7, IC 1, F 1	SSW	4	10
31	33	5	19	T	T	3	SW 1	W	14	28
Totals	33	-13	11.32	.19	4.7	3 max		WNW	7 ave	31 max

Table BII (cont'd).

Date 1972 January	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	29	14	22	0	0	3		W	13	22
2	21	4	12	.01	.4	3	S- 7, BS 2	NW	10	26
3	6	-10	-2	T	T	4	S- 2, DS 1	NW	8	24
4	3	-13	-5	0	0	4	DS 2	WSW	9	27
5	21	-1	10	T	T	4	S- 2, BS 2	SSW	10	27
6	34	8	21	T	T	3	S- 3, DS 4, BS 3	WNW	14	48
7	28	6	17	0	0	3		S	7	24
8	38	22	30	T	T	3	BS 1	SW	12	35
9	20	3	12	.03	.6	2	BS 1, S- 11	VAR.	10	32
10	17	3	10	.01	.2	3	S- 4, BS 1	WNW	13	23
11	11	-5	3	0	0	3		SE	8	21
12	13	-10	2	.01	.1	3	S- 7, DS 4, BS 12	N	14	30
13	-8	-23	-16	T	T	3	BS, S- 15	N	11	24
14	-22	-26	-24	0	0	3	BS 4, DS 5	NW	12	27
15	-8	-31	-20	T	T	3	BS 8, S- 4	S	13	31
16	41	-6	18	.02	.2	3	S- 6, BS 5	SSW	16	35
17	38	18	28	0	0	2		SW	8	20
18	14	-7	4	T	T	1	S- 16, BS 1	NNW	13	27
19	-1	-9	-5	.01	.2	1	S-8	SE	4	10
20	-1	-14	-8	.01	T	1	S-1, DS 4, BS 5	N	8	23
21	14	-10	2	T	.1	1	S-18, DS 1, BS 10	S	14	32
22	-1	-6	-4	T	T	1		NNW	9	20
23	7	-4	2	T	.3	1	S- 11	VAR.	5	16
24	1	-16	-8	.07	3.2	4	S-18, DS 2, BS 16	N	17	36
25	-15	-23	-20	0	0	4	BS 2, DS 5	NW	10	29
26	-11	-24	-18	0	0	4		WNW	8	20
27	-7	-19	-13	0	0	4		W	8	15
28	-5	-17	-11	0	0	4		SW	8	16
29	-2	-17	-10	0	0	4		WNW	6	12
30	6	-18	-6	.01	.3	3	S- 5	S	7	17
31	12	-1	6	T	T	3	S- + SW 4	NNW	5	14
Totals	38	-31	1	.18	5.6	4		WNW	9 ave	48 max

Date 1972 February	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	3	-10	-4	T	T	3	F, IC 6, S- 3	N	7	17
2	4	-16	-6	0	0	3		W	4	11
3	5	-8	-2	T	T	3	S- 18, F 1, BS 2	NNW	9	20
4	-4	-14	-9	0	0	3		NW	6	13
5	-2	-11	-6	T	T	3	S-7, IC 2	N	5	17
6	-4	-15	-10	0	0	3		NW	6	14
7	0	-21	-10	0	0	2		W	2	8
8	-5	-19	-12	0	0	2		NNW	3	10
9	0	-20	-10	0	0	2		S	3	10
10	11	-9	1	T	T	2		SSW	12	23
11	28	3	16	0	0	2	BS 1	S	11	26
12	29	10	20	0	0	2		NW	10	28
13	37	12	24	T	T	1	SW 1	SSW	11	29
14	27	0	14	T	T	1	S- 7, BS 10	N	12	25
15	17	-4	6	T	.3	1	S- 11	S	7	16
16	22	5	14	T	T	1	S- 21	SE	9	20
17	21	4	12	.09	1.6	2	S 18, ZR 5, BS 9, F 8	NNW	16	41
18	14	-4	5	T	T	2	F 6, BS 1	NNW	8	20
19	22	-1	10	0	0	1		SE	8	20
20	28	11	20	T	T	1		S	11	21
21	13	-1	6	T	T	1	S- 4, IC 3, BS 1	NNW	13	31
22	10	-3	4	T	T	1	S- 1	SSE	9	22
23	10	0	5	.07	1	2	S- 15, DS 1, BS 14	N	16	31
24	9	-4	2	T	T	2	S- 10	SSW	4	10
25	10	-6	2	0	0	2		WNW	5	15
26	7	-1	3	.01	.5	2	S- 13	N	4	13
27	4	-1	2	.06	1.2	3	S- 24	N	7	13
28	6	2	4	.03	.6	4	S- 10, IC 6	N	8	18
29	6	-4	1	.05	.9	4	S- 15, BS 10	NNE	11	27
Totals	37	-21	4	.31	6.1	4		NNW	8 ave	41 max

Table BII (cont'd). Station: Grand Forks AFB, N.D.

Date 1972 March	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	-1	-19	-10	T	T	5	BS 1, S- 3	N	11	26
2	2	-20	-9	T	T	5	S-1	S	5	14
3	7	-2	2	.17	3.1	6	S- 21, BS 15	NE	14	28
4	6	-9	-2	0	0	6		NNW	10	18
5	8	-8	0	0	0	6	ZL 1	WNW	5	18
6	39	7	23	.03	.8	5	S- 10, DS 6, BS 3	S	18	51
7	16	1	8	T	T	4	BS + S- 5	NW	22	45
8	19	-8	6	.01	.8	3	S- 5	W	6	14
9	10	-5	2	0	0	4		VAR.	4	9
10	34	4	19	T	T	4	DS 1, BS 2	S	13	36
11	29	17	23	0	0	4		N	7	20
12	29	17	23	0	0	3		N	2	6
13	38	19	28	0	0	1	F 24	SSE	5	14
14	40	30	35	T	0	T	R + F 1, F 15	S	11	21
15	44	30	37	.1	0	T	R + F 2, R 2	NW	8	26
16	51	32	42	0	0	T		NNW	9	20
17	40	31	36	T	T	T	S- 1	NNE	8	19
18	41	34	38	T	0	0	R 1	S	8	19
19	39	32	36	T	0	0	F 18, L- 6	NNE	5	11
20	49	29	39	.02	0	0	R 1, F 18	NW	3	20
21	40	29	34	0	0	0		NNW	14	25
22	31	26	28	0	0	0		N	10	22
23	36	23	30	0	0	0		E	7	16
24	38	25	32	0	0	0		SE	7	18
25	37	27	32	0	0	0		ESE	5	14
26	35	26	30	.15	3	0	S- 9, BS 5	E	11	26
27	29	24	26	.20	5.2	6	S- 24, BS 14, DS 10	E	12	25
28	30	16	-23	.02	.3	9	S- 12, BS 6	WNW	9	19
29	30	15	22	T	T	9	SW 1	W	6	13
30	29	11	20	T	T	8		WNW	6	13
31	32	25	28	T	T	7	S- 7	NNW	14	30
Totals	51	-20	22	.7	13.2	9		NW	9 ave	51 max

Date 1972 April	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	35	20	28	0	0	1		NNW	9	-
2	38	23	30	T	T	0	R + S- 3	SSE	13	35
3	24	17	20	T	T	T	SW 1	NW	15	28
4	29	11	20	T	T	T	S- 3	WNW	14	28
5	38	17	28	0	0	T		E	5	-
6	35	26	30	.05	.5	0	S-5, RW - IP 1	ENE	13	28
7	32	21	26	.03	.3	1	S- 2	SE	13	-
8	35	26	30	.02	.2	T	S- 4, BS 2	S	16	28
9	37	31	34	T	T	T	F 12, R 1, ZR 1, S- 2	S	12	-
10	42	31	36	0	0	0		NNW	10	-
11	34	27	30	.02	.2	0	S-5, F 7, L- 1	SSE	5	-
12	36	31	34	1.87	8	0	R + F 9, S- 8	E	10	-
13	38	31	34	.05	.4	3	S- 2, F + L- 2	N	8	-
14	49	32	40	0	0	0		SSW	8	-
15	64	35	50	0	0	0		WSW	13	-
16	51	37	44	0	0	0		NNW	11	25
17	42	33	38	.05	T	0	R 1, S- 1	NE	14	-
18	49	31	40	0	0	0		NNE	11	-
19	54	32	43	0	0	0		NW	6	-
20	55	32	44	0	0	0		S	7	-
21	48	36	42	.06	0	0	R 4, F 1	ENE	6	-
22	43	33	38	.23	0	0	R 6, RW 6, L- 6, F 6	NNE	11	-
23	44	32	38	.17	1	0	R + F 3, S- 6, L- 4, F 2	N	10	-
24	49	31	40	0	0	0		N	4	-
25	55	32	44	0	0	0		SSE	13	28
26	56	36	46	T	0	0	L- 1	S	10	16
27	62	41	52	T	0	0	R 6, F 2	ENE	7	-
28	66	36	51	0	0	0		E	8	22
29	64	39	52	0	0	0		SSE	9	18
30	63	44	54	T	0	0		ESE	8	-
Totals	66	11	38	2.55	10.6	3		NW+SSE	10 ave	35 max

Table BIII. Station: Minot AFB, N.D.

Date 1971 November	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	30	26	28			2		WNW	6	15
2	38	29	34			1		NW	17	34
3	34	20	27			1		NW	10	30
4	35	16	26	.01		1	RW 3	SE + WNW	14	41
5	26	10	18	T	T	1	SW 7, BS 9, S- 13	WNW	30	53
6	16	5	10			T	BS 5	NW	23	42
7	25	2	13			T		SE	10	25
8	45	19	32			T		WNW	11	38
9	55	29	42			T		W	6	25
10	53	27	40			0		SW	4	-
11	50	30	40			0		W + SE	4	-
12	50	29	40			0	F 4	VAR.	3	-
13	41	29	35	.01		0	F 22, L- 3	ESE	5	16
14	37	35	36	.01		0	F 24, L- 14	NW	3	-
15	37	28	33	T		0	L- 1, F 4	NW	8	18
16	35	27	31			0		VAR.	3	-
17	34	20	27	.08	.8	1	S- 14 .	NW - S	6	20
18	28	16	22	.02	.2	1	S- 9	NW	11	24
19	46	20	33	T	T	T	RW 1, S- 3	WNW + S	11	30
20	38	18	28			0		NW	13	28
21	32	14	23			0		SSE	8	23
22	46	29	38			0		WSW	11	26
23	36	26	31	T	T	0	SW, S- 12	NW	12	30
24	26	19	22	T	T	0	S- 6	N + ESE	5	-
25	32	22	27	T	T	T	S- 9	ESE	9	16
26	24	21	22	T	T	T	ZL 2, F 3, S- 12	[illegible]W + SW	5	-
27	28	16	22	.05	.5	T	IC 1, ZL 3, F 7, S- 12	ENE	8	-
28	18	9	13	.04	.4	1	IC 6, S- 24	ESE	9	19
29	13	5	9	T	T	1	IC 9, S- 13	SSE	6	-
30	24	5	15	T	T	1	IC 10, S- 11	SE	4	-
Totals	55	2	27	.22	1.9	2 max		[illegible] + SE	9 ave	53 max

Date 1971 December	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	34	17	26	T	T	1	S- 2	SW	7	14
2	37	17	27			1		S	9	24
3	29	20	24	T		T	ZL 6, F 4, S- 17	SE	11	25
4	31	23	27	T	T	T	F 7	SE + WSW	7	18
5	25	8	16			T		VAR.	3	-
6	21	12	16	.01	.1	T	DS 3, F 9, S- 18	NNE	6	19
7	12	-2	5	T	T	T	IC 8, DS 1, S- 15	N	9	23
8	13	-5	4	T	T	1	IC 1	WSW	8	26
9	31	9	20	T	T	T	S- 2	S	11	25
10	29	3	16			1		WNW	14	31
11	4	-4	0			T		NW	15	32
12	4	-8	-2			T		NW	7	24
13	9	-7	1	.03	.3	1	IC 7, S- 8	ENE	7	-
14	17	-2	7	T	T	1	IC 8, S- 1	SE	8	20
15	19	-4	8	T	T	T	S- 4	NW	12	25
16	-2	-17	-10	T	T	T	SW 1	NW	11	27
17	21	-17	2			T	IC 1, F 2, S- 11	SSW	4	-
18	30	6	18	.08	.5	1	IC 1, F 2, S- 11	VAR.	5	21
19	25	0	13			1		SSW	8	21
20	25	0	13			1		NW	12	26
21	14	-2	6	T	T	1	IC 2, S- 1, SW 5	N + SE	10	25
22	22	9	16	T	T	1	IC 5, S- 8, F 14, ZL 5	ESE	11	22
23	20	-9	6	.02	.	1	F 14, S- 5, ZL 10	NNW	12	30
24	4	-15	-6	T	T	1	S- 2	SE	8	21
25	3	-10	-4	.06	[illegible]	1	S- 4, BS 3	NW	14	24
26	-4	-16	-10			2		NW	8	20
27	10	-3	4			2		NW	12	21
28	22	5	13			2		WNW	11	26
29	13	-4	4	T	T	1	IC 3, F 2, S- 1	VAR.	4	-
30	15	-2	6			1		WNW	8	20
31	35	15	25			1		SSW	17	31
Totals	37	-17	9	.20	2.0	2 max		WNW	9 ave	32 max

Table BIII (cont'd). Station: Minot AFB, N.D.

Date 1972 January	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	25	17	21			1		W	14	28
2	20	-2	10			1		NW	11	24
3	0	-9	5	T	T	1	IC 2	NW	11	26
4	19	-16	1			1		SW	10	24
5	23	9	16	T	T	1	IC 1, S- 1	W	12	30
6	35	21	28			1	BS 1	WNW	19	43
7	32	9	20			T		WNW + SE	7	-
8	37	4	21	T	T	T	ZR 1, S- 1, BD 8	W	17	43
9	21	2	11	.12	1.2	T	S- 15, IC 3	ESE	8	23
10	32	28	30			1		NW	9	28
11	15	-8	4	T	T	1		SE	8	20
12	8	-6	1	.03	0.3	2	S- 18, IC 11, BS 1, DS 8	NW	12	30
13	-7	-28	-17	.03	0.3	2	S- 11, DS 1, IC 5, BS 8	NW	16	26
14	-23	-30	-27	T	T	2	BS 8, IC 4, DS 1	NW	17	31
15	13	-32	9	T	T	2	S- 5, IC 5	SSE	12	29
16	45	15	30			2		WNW	13	29
17	45	19	32			1		W	11	24
18	15	-11	2	.01	T	T	IC 2, BS 1, S- 8	NW	17	31
19	-5	-14	-9	.03	.3	T	S- 24	E + NW	6	-
20	-2	-15	-9	.11	1.1	1	S- 8, DS 2, IC 1	NW + SE	12	26
21	23	-6	9	T	T	2	BS 6, DS 3, IC 9, S- 6	NW + SSE	15	30
22	-2	-12	-7	.01	.1	2	S- 3, IC 1	WNW	10	20
23	4	-8	-2	.03	.3	2	S- 14	N + SE	9	-
24	-8	-24	-16	.05	.5	2	BS 8, S- 17	NNW	15	32
25	-22	-30	-26	T	T	2	IC 6	NW	11	26
26	-15	-29	-22			2		NW	11	19
27	-10	-22	-16			2		W	9	-
28	-5	-28	17			1		W	7	-
29	-1	-16	-9	T	T	1	IC, S- 2	NW	10	-
30	25	-3	11	T	T	1	S- 13	NW	12	32
31	22	3	13	.01	.1	1	S- 14	NNW	10	24
Totals	45	-32	4	.43	4.2	2 max		NW	12 ave	43 max

Date 1972 February	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	4	-11	-3	T	T	1	IC 1, SW 2	NW	9	17
2	5	-12	-3	T	T	1	IC 1, DS 3	WNW	11	26
3	4	-9	-3	T	T	1	S- 1	NW	11	-
4	-2	-16	-9	T	T	T	S- 1	NW + ESE	7	-
5	0	-13	-7	.05	.5	1	IC 21, S- 19	E	9	-
6	-5	-20	-13	T	T	1	S- 1, IC 13	VAR.	2	-
7	-3	-21	-12	.04	.4	1	S- 9, IC 12	ENE	5	-
8	-2	-26	-14	.02	.2	2	S- 2, IC 7	VAR.	5	-
9	-3	-24	-13	T	T	2	S- 5, IC 24	SE	9	-
10	16	-9	3	T	T	2	IC 10	SSW	9	30
11	35	17	21			2	DS 1	SW	11	27
12	34	21	27			2		WNW	16	36
13	43	26	35	T	T	1	S- 1	WNW	16	33
14	32	10	21	T	T	T	S- 14, IC 11	NW	12	28
15	23	6	15	.01	.1	T	S- 15, IC 3	WNW + SE	10	17
16	32	16	24	.12	1.2	T	S- 24, IC 4, ZL 2	SE + NW	12	50
17	20	3	11	T	T	1	S- 8, BS 19	NW	22	58
18	25	-1	12			1		NW + SE	5	-
19	31	15	23			1		SSE	7	-
20	25	4	15	.01	.1	1	S- 2, IC 1	NW	8	24
21	8	-4	2	T	T	T	S- 3, IC 1	NW	15	31
22	18	-4	7	.15	1.5	T	BS 10, IC 3	E	12	28
23	6	-3	1	.24	2.4	4	BS 10, IC 11, S- 24	NE	10	26
24	7	-14	-3	.01	0.1	4	S- 6, IC 9	SE + NW	6	-
25	6	-14	-4	T	T	4	S- 1	NW	6	-
26	-5	-13	-9	.05	0.5	4	S- 16, IC 13	NNW	6	-
27	-3	-7	-5	.12	1.8	5	S- 24, IC 15	E	7	-
28	6	2	4	.02	0.2	7	S- 20, IC 7	N + ENE	8	-
29	5	-6	0	.23	2.3	7	S- 24, IC 4	ENE	10	-
Totals	43	-26	4	1.07	11.3	7 max		NW + E	10 ave	58 max

Table BIII (cont'd).

Date 1972 March	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	-6	-23	-14	T	T	9	S- 7, IC 19	E + SW	4	-
2	0	-24	-12	.09	.9	7	IC 17, S- 7, DS 1	SW + SE	8	25
3	1	-18	-9	.07	.7	7	IC 22, S- 11, DS 8	SSE	12	25
4	2	-20	-9	T	T	8	IF 1, S- 6, IC 11	W	5	-
5	20	-16	2	.01	.1	6	IC 8, S- 5, ZR 1, BS 1	W + SE	12	25
6	44	10	27	T	T	5	S- 2, IC 1	WSW	21	51
7	13	1	7	T	T	3	IC 8, BS [illegible]	WNW	21	39
8	22	-5	9			3		WNW	8	26
9	16	6	11	.02	.2	2	S- 7	ESE	7	-
10	43	11	27	T	T	2	S- 1	SE + SW	7	21
11	32	22	27			1	F 1	N	6	-
12	37	23	30			1	F 7	S	8	-
13	43	32	38			1	F 10	S	11	4
14	42	32	37	.02	0	T	F 8, RW 4	S + WNW	9	22
15	47	34	40			T		WNW	15	34
16	49	34	42			T		WNW	7	-
17	38	31	35	.20	.3	0	R- 5, S- 5	E + SSW	7	-
18	54	35	44			T	F 3	SW + NE	6	-
19	38	33	36	T		0	F 18, L- 16	E	5	-
20	56	35	46	.01			L- 7, F 7	SSW + NW	9	24
21	45	28	36					NW	10	25
22	42	27	34					ENE	7	-
23	42	27	34					ESE	17	27
24	38	33	36	.12	1.2		S- 15, F 10, R 1	SE	13	25
25	34	25	30	.04	.3	T	S- 10, L- 10, F 18, ZL 2	ESE	13	22
26	32	25	28	.25	2.5	T	S- 23, BS 10	SSE + SSW	18	31
27	28	18	23	.11	1.5	4	S- 15, IC 2, BS 6	ENE + N	11	23
28	26	13	20	T	T	2	S- , SW 7, IC 1	NW	9	24
29	30	16	23	.02	.2	2	SW 6	WNW	8	-
30	29	13	21	T	T	2	SW 4	NW	9	[illegible]
31	34	18	26			1	F 3	NW	8	-
Totals	56	-24	23	0.96	7.9	9 max		WNW + SE	10 ave	51 max

Date 1972 April	Temperature(°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hrs.	Wind (kt) Dir.	Speed	Peak Gust
1	38	18	28			4		SW + SE	9	-
2	36	23	30	T	T	4	R 1	SE + WNW	17	37
3	26	15	20	T	T	2	SW 1	WNW	16	30
4	34	13	24			2		W	11	25
5	50	23	36			2		ESE	[illegible]	-
6	40	28	34	T		1	RW 1	E	16	25
7	36	29	32	.14	.03	1	ZR 1, L- 4, S- 3, ZL 3, R 1, F 10	ESE	15	24
8	55	34	44			1		SW + SE	11	-
9	56	34	45			T	F 4	SSE + WSW	11	24
10	45	34	40			0		WNW	11	-
11	37	[illegible]	35	.42	4.2	1	S- 4, F 9, S 2, L- 5, IP- 1	ESE	11	-
12	36	34	35	.06		1	R 5, F 22, L- 2	SE + NE	9	-
13	44	36	40	T		0	L- 5, F 10	NW	6	-
14	57	30	44					WSW	10	-
15	66	39	52	T			R 1	W	16	27
16	50	33	42	T	T		R 2, S- 3	WNW + NE	13	25
17	41	30	36	T	T		S- 5	NE + NW	12	26
18	48	27	38				F 1	W + ENE	6	-
19	54	34	44					WSW	7	-
20	53	36	44					SSE	12	-
21	57	35	46					SE	10	-
22	44	27	36	T			RW 5, F 2, L- 4	VAR.	6	-
23	46	34	40	.01			R- 4	WNW	13	-
24	50	31	40				F 5	SE	9	-
25	62	32	47					SE	17	32
26	53	44	48	.02			R 7, F 5	S	12	-
27	56	41	48	T			R 1, F 7	VAR.	6	-
28	63	36	50				F 3, F 1	SE	8	-
29	60	36	48				F 3	ESE	13	25
30	60	43	52				F 9	ESE	10	-
Totals	66	13	40	0.65	4.5	4 max		WNW	11 ave	37 max

Table BIV. Comparison of drifting or blowing snow, freezing rain or freezing drizzle and significant snow storms, 1971-1972.

Date	Nekoma, N.D.			Grand Forks, N.D.			Minot, N.D.		
Nov. 1971	Storm Type+	Duration (hrs)*	Amt. (in.) (water Eq.)	Storm Type	Duration (hrs)	Amt. (in.) (w. Eq.)	Storm Type	Duration (hrs)	Amt. (in.) (w. Eq.)
1	S	6 to <12	0.20	S	7	0.20			
2				S	3	0.03			
3									
4	S	<6	0.05						
5				BS/DS	9	-	S,BS	10,9	0.01
6				BS/DS	8	-	BS	5	-
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17	S	6 to <12	0.08				S	12	0.08
18	S	6 to <12	0.03	S	6	0.02	S	3	0.02
19	S	<6	0.05						
20									
21	S	Con't	Con't						
22	S	6 to <12	0.03						
23	S	<6	0.02						
24									
25									
26							ZL	2	T
27	S	Con't	Con't	ZL	7	T	S,ZL	10,3	0.05,T
28	S	6 to <12	0.03				S	8	0.04
29	S	<6	0.02						
30									

Date	Nekoma, N.D.			Grand Forks, N.D.			Minot, N.D.		
Dec. 1971	Storm Type+	Duration (hrs)*	Amt. (in.) (water Eq.)	Storm Type	Duration (hrs)	Amt. (in.) (w. Eq.)	Storm Type	Duration (hrs)	Amt. (in.) (w. Eq.)
1									
2									
3				S	Con't	Con't	ZL	6	T
4	S	12 to <18	0.10	S,ZL/ZR	21,2	0.01,T			
5	S	<6	0.01						
6				S	6	0.06	BS,S	1,13	-,0.01
7				BS/DS	21	-	DS	1	-
8									
9				BS	3	-			
10				BS	1	-			
11									
12									
13	S	<6	0.01	S	Con't	Con't	S	6	0.03
14				S	12	0.04			
15				ZL,S	2,5	T,0.06			
16									
17									
18							S	8	0.08
19				S	2	0.01			
20	S	6 to <12	0.03	BS	2	-			
21									
22				ZL	Con't	Con't	ZL	Con't	Con't
23	S	18 to <24	0.06	ZL,BS	25,1	T,-	ZL,S	15,5	T,0.02
24									
25				BS,ZL	3,1	-,T	S,BS	4,3	0.06,-
26									
27									
28									
29									
30				S	5	0.01			
31	S	<6	0.01						

Significant snowstorms exclude all periods when only a trace of snow was recorded or when the visibility exceeded 6 miles.
+ Events of blowing or drifting snow and freezing rain or freezing drizzle were not recorded at Nekoma.
* Only 6-hour intervals of storm duration were available at Nekoma.

Con't = Continued into next day

Table BIV (cont'd).

Date Jan. 1972	Nekoma, N.D. Storm Type+	Duration (hr)*	Amt.(in.) (water Eq.)	Grand Forks, N.D. Storm Type	Duration (hr)	Amt.(in.) (w. EQ.)	Minot, N.D. Storm Type	Duration (hr)	Amt.(in.) (w.Eq.)
1									
2	S	Con't	Con't	S,BS/DS	4,Con't	0.01,-			
3	S	6 to <12	0.04	BS/DS	3	-			
4				DS	2	-			
5				BS	2	-			
6	S	6 to <12	0.03	BS/DS	7	-	BS/DS	3	-
7									
8	S	<6	0.01	BS	Con't	-	ZR	1	T
9	S	<6	0.05	BS,S	2,Con't	Con't	S	15	0.12
10				S,BS	15,1	0.04,-			
11									
12				S,BS/DS	4,16	0.01,-	S,BS/DS	Con't ,9	Con't ,-
13				BS	15	-	S,BS/DS	23,9	0.06,-
14				BS/DS	9	-	BS/DS	9	-
15				BS	Con't	-			
16	S	<6	0.05	BS,S	13,10	0.02			
17									
18				BS	1	-	BS,S	1,8	-,0.01
19	S	Con't	Con't	S	Con't	Con't	S	Con't	Con't
20	S	6 to <12	0.05	S,BS/DS	9,9	0.02,-	S,DS	21,2	0.14,0
21	S	6 to <12	0.02	BS/DS	11	-	BS/DS	9	-
22							S	3	0.01
23							S,S	10,Con't	0.03,Con't
24	S	<6	0.05	S,BS/DS	13,18	0.07,-	S,BS	17,8	0.65,-
25				BS/DS	7	-			
26									
27									
28									
29									
30				S	3	0.01			
31	S	Con't	Con't				S	4	0.01

Date Feb. 1972	Nekoma, N.D. Storm Type+	Duration (hr)*	Amt.(in.) (water Eq.)	Grand Forks, N.D. Storm Type	Duration (hr)	Amt.(in.) (w.Eq.)	Minot, N.D. Storm Type	Duration (hr)	Amt.(in.) (w.Eq.)
1	Con't,S	Con't,6to<12	Con't,0.03						
2	S	<6	0.01				DS	3	-
3				BS	2	-			
4									
5							S	18	0.05
6									
7							S	Con't	Con't
8							S	11	0.06
9									
10									
11				BS	1	-	DS	1	-
12									
13									
14				BS	10	-			
15							S	4	0.01
16	S	<6	0.02	S	Con't	Con't	ZL,S	2,Con't	T,Con't
17	S	6 to<12	0.08	S,ZR,BS	30,5,Con't	0.09,T,Con't	S,BS	16,19	0.12 ,-
18	S	<6	0.01	BS	10	-			
19									
20							S	2	0.01
21				BS	1	-			
22	S	Con't	Con't				BS		
23	S	6 to< 12	0.15	S,BS/DS	12,15	0.07,-	BS,S	20,24	-,0.39
24	S	6 to< 12	0.06				S	4	0.01
25									
26	S	Con't	Con't	S	Con't	Con't	S	Con't	Con't
27	S	Con't	Con't	S	Con't	Con't	S	Con't	Con't
28	S	24 to <30	0.14	S	30	0.10	S	Con't	Con't
29	S	12 to< 18	0.15	,BS	13,10	0.05,-	S	42	0.42

Significant snowstorms exclude the periods when only a trace of snoe was recorded or when the visibility exceeded 6 mile.
+ Events of blowing or drifting snow and freezing rain or freezing drizzle were not recorded at Nekoma.
* Only 6-hour intervals of storm duration were available at Nekoma.

Con't = Continued into next day

Table BIV (cont'd). Comparison of drifting or blowing snow, freezing rain or freezing drizzle and significant snow storms, 1971-1972.

Date March 1972	Nekoma, N.D. Storm Type+	Nekoma, N.D. Duration (hr)*	Nekoma, N.D. Amt. (in.) (w.eq.)	Grand Forks, N.D. Storm Type	Grand Forks, N.D. Duration (hr)	Grand Forks, N.D. Amt. (in.) (w.eq.)	Minot, N.D. Storm Type	Minot, N.D. Duration (hr)	Minot, N.D. Amt. (in.) (w.eq.)
1									
2				S	Con't	Con't	DS,S	1,Con't	-,Con't
3	S	6 to < 12	0.05	S,BS/DS	22,16	0.17,0	S,DS	17,8	0.16,-
4	S	< 6	0.03						
5	S	Con't	Con't	ZL	1	T	BS,ZR,S	1,1,5	-,T,0.01
6	S	6 to < 12	0.09	S,BS/DS	7,9	0.03,-			
7				BS	5	-			
8				S	5	0.01			
9							S	6	0.02
10				BS/DS	3	-			
11									
12									
13									
14									
15									
16									
17							S	4	0.03
18									
19									
20									
21									
22									
23									
24							S	Con't	Con't
25							S,ZL	19,2	0.12,T
26	S	Con't		S,BS	Con't	Con't	S,BS	Con't	Con't
27	S	Con't		S,BS/DS	Con't,29	Con't	S,BS	31,16	0.36,-
28	S	30 to < 36	0.30	S,BS	43,6	0.37,-			
29							S	3	0.02
30									
31									

Date April 1972	Nekoma, N.D. Storm Type+	Nekoma, N.D. Duration (hr)*	Nekoma, N.D. Amt. (in.) (water Eq.)	Grand Forks, N.D. Storm Type	Grand Forks, N.D. Duration (hr)	Grand Forks, N.D. Amt. (in.) (w. Eq.)	Minot, N.D. Storm Type	Minot, N.D. Duration (hr)	Minot, N.D. Amt. (in.) (w. Eq.)
1									
2									
3									
4									
5									
6	S	< 6	0.05	S	Con't	Con't			
7	S	Con't	Con't	S	7	0.08	S,ZL	3,Con't	0.03,Con't
8	S	6 to < 12	0.05	S,BS	4,1	0.02,-	ZL/ZR	4	T
9				ZR	1	T			
10									
11	S	< 6	0.03	S	5	0.02	S	6	0.42
12				S	Con't	Con't			
13				S	10	0.93			
14									
15									
16									
17	S	6 to < 12	0.05						
18									
19									
20									
21									
22									
23				S	6	0.13			
24	S	< 6	0.07						
25									
26									
27									
28									
29									
30									

Significant snowstorms exclude all periods when only a trace of snow was recorded or when the visibility exceeded 6 miles.

+ Events of blowing or drifting snow and freezing rain or freezing drizzle were not recorded at Nekoma.

* Only 6-hour intervals of storm duration were available at Nekoma.

Con't = Continued into next day

Table BV. Station: Nekoma, N.D.

Date 1972 November	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	26	4	15					SSE	6	
2	29	4	16	.03		8*	ZL6,F6	NNE	6	
3	34	21	28	.02		5	L-6	WSW	8	
4	34	28	31	.02		4	ZL3	SSE	7	21
5	35	28	32	.05	T	4	L-6,R3,S6,F6	E	11	25
6	30	17	24	.05	T	3	ZR3,S12	N	16	27
7	21	15	18			3		N	9	
8	28	18	23	.02	T	3	S12,F6	SE	5	
9	29	25	27	.03		3	ZL3,ZR3,F6	WNW	5	
10	31	23	27	.04		3	ZL3,ZR3,F6	NNW	6	
11	31	23	27	.01		3	ZL3	N	7	
12	25	2	14	.01	T	3	S6	NE	7	
13	18	-1	8	.01		3	L-3	NE	3	
14	22	2	12			3		S	5	
15	29	16	22			3		S	9	22
16	26	23	24	.03	T	3	S18	NW	8	
17	24	18	21	.01	T	3	S6	NW	4	20
18	27	17	22	.04	.5	3	S18	SSE	4	
19	[illegible]	22	26	.03	T	3.5	S18	NE	5	
20	27	12	20	.03	T	3.5	S18	NNE	4	
21	27	12	20	.02	T	3.5	S12,F6	S	5	
22	26	20	23	.02	T	3.5	S12,BS6	WSW	11	27
23	35	19	27			3.5		SW	8	21
24	37	22	30	.02	T	3.5	S6,L-3	WSW	7	21
25	32	17	24			3	BS6	NNW	17	35
26	29	22	26	.10	1.5	3	S12	NNW	10	32
27	18	0	9	.05	.5	5	S18, BS6	N	10	32
28	12	-8	2	.01	T	5	S6	WNW	7	
29	28	-4	12			5		SW	11	29
30	28	6	17	.03	.5	5	S6	NNW	7	22
TOTALS	37 max	-8 min	21 ave	.68	3.0	8 max		NW & SSE	8 ave	35 max

*Snow on ground measurements began on 2 November.

Date 1972 December	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	10	-16	-3	.02	T	6	S6	NNW	8	28
2	-4	-16	-10			6		NW	9	
3	-3	-19	-11			6		WNW	9	20
4	-4	-20	-12	.02		6	ZL-12	WSW	8	
5	-8	-23	-16			6		NW	7	20
6	-11	-28	-20			6		W	9	22
7	-11	-26	-18			6		W	6	
8	-10	-20	-15		T	6		W	8	
9	-6	-26	-16			6		W	5	
10	0	-26	-13			6		WSW	8	23
11	9	-14	-2			6		SSW	8	20
12	10	-11	0			6		NW	7	
13	5	-14	-4			6		WSW	5	
14	14	-12	1			6		SSW	6	
15	-3	-24	-14			6		NW	6	
16	14	-24	-5			6		S	9	36
17	26	2	14	.01		6	ZL-6	VAR	9	35
18	26	2	14	.04	T	6	S24	VAR	8	30
19	11	-3	4	.06	.5	6	S6	SE	10	29
20	18	8	13	.03	.25	6.5	S18,F6	NNW	10	27
21	25	-1	12			6.5		S	10	35
22	29	7	18			6.5	F6	NE	6	
23	7	-8	0		T	6.5	BS3	N	6	
24	18	-7	6	.01	.25	6.5	S6	S	6	
25	8	-4	2	.03	.25	6.5	S18	NNW	10	22
26	33	-3	15			6.5		SW	7	20
27	29	2	16	.01	T	6.5	S6	WNW	7	22
28	24	16	20	[illegible]	.5	6.5	S24,BS6,F6	E	13	33
29	18	2	10	[illegible]	2.0	7	S24,BS6	NE	19	33
30	4	-1	2	.66	2.0	7	S24,BS24	NNE	25	43
31	9	-10	0	.54	.5	7	S24,BS12	N	18	37
TOTALS	33 max	-28 min	0 ave	1.57	6.3	7 max		WNW	9 ave	43 max

Table BV (cont'd). Station: Nekoma, N.D.

Date	Temperature (°F)			Precipitation(in.)				Wind (kt)		
1973 January	Max	Min	Ave	Precip	Snow Fall	Snow on Ground	Type + Hours	Dir.	Speed	Peak Gust
1	18	-7	6	.08	.5	7	S18	NW	8	
2	24	8	16	.03	T	7	S12	S	9	28
3	8	-10	-1			7	BS12	NW	14	31
4	-6	-16	-11			7		NW	6	
5	-11	-25	-18			7		VAR	3	
6	1	-23	-11			7		S	2	
7	-8	-29	-18			7			CALM	
8	-4	-29	-16			7		W	5	
9	-4	-16	-10			7	BS6	W	12	27
10	9	-10	0	.01	T	7	S6, BS6	NW	12	26
11	13	-10	2			7		W	9	20
12	29	2	16	.03	.2	7	S18	W	9	25
13	31	10	20	.04	T	7	S18	WSW	4	
14	35	14	24	.01	T	6.5	S6	NW	12	40
15	38	15	26	.01	T	6.5	S6	SSW	10	26
16	38	24	31	.01		6	ZL6	SSW	6	
17	34	13	24			5.5		ESE	6	
18	30	-3	14	.05	.3	6	S24	NW	14	30
19	12	-3	4			6		ENE	5	
20	22	-2	10	.01		6	ZL3	S	9	23
21	26	11	18	.02		6	ZL6, F6	SSW	9	21
22	28	2	15			6		NNW	14	37
23	38	4	21			5		WNW	10	21
24	42	21	32			5		WSW	12	29
25	42	25	34			4		WSW	5	
26	32	10	21	.02	T	3	S12	NNE	18	36
27	17	2	10	T	T	3		N	16	33
28	24	-3	10	.01		3	ZL3	WSW	8	23
29	34	6	20			2		VAR	7	
30	24	11	18	.01		2	ZL3, F6	SE	10	23
31	28	18	23	.01		2	ZL3	SSE	10	21
TOTALS	42 max	-29 min	11 ave	.35	1.0	7 max		NW & SSW	9 ave	40 max

Date	Temperature (°F)			Precipitation(in.)				Wind (kt)		
1973 February	Max	Min	Ave	Precip	Snow Fall	Snow on Ground	Type + Hours	Dir.	Speed	Peak Gust
1	24	12	18	.01		2	ZL3, F6	N	8	
2	38	8	23	.01		2	ZL3	WSW	6	
3	38	14	26			2		VAR	7	22
4	26	6	16	.01	T	2	S6	NNE	11	25
5	31	2	16	.06	.5	2	S24	SSE	14	34
6	10	-10	0			2.5		W	15	29
7	12	-8	2			2.5		WNW	10	25
8	20	-7	6			2.5		WSW	7	
9	10	-13	-2			2.5		N	6	
10	18	-11	4			2.5	BS6	SSE	12	28
11	26	10	18			2.5		SE	10	20
12	22	3	12	T		2	F6	NNE	7	
13	2	-15	-6	.09	.5	2.5	S24, BS6	N	21	34
14	-6	-20	-13	.02		2.5	ZR6, BS6	NNE	16	25
15	-8	-22	-15	.02		2.5	ZR6	NE	9	
16	16	-20	-2	.02	.2	2.5	S6	S	15	36
17	25	9	17	.01		2.5	ZL3	VAR	6	
18	38	11	24	.02	T	2	S12	SSW	12	27
19	19	3	11	.01	T	2	S6	NNW	11	24
20	27	4	16	.01	T	2	S6, BS6	N	14	27
21	37	-4	16			2		SSW	12	28
22	42	19	30			1.5		WNW	10	
23	22	7	14			1.5		NE	13	22
24	24	2	13			.5		E	8	
25	26	12	19					ENE	11	23
26	30	16	23	.04	.2		S18, BS24	S	9	23
27	19	9	14	.01	T		S6	ENE	11	23
28	32	19	26	.02	T		S6, F6	NNW	5	
TOTALS	42 max	-22 min	12 ave	.36	1.4	2.5 max		N & ENE	11 ave	36 max

Table BV (cont'd).

Date	Temperature (°F)			Precipitation(in.)				Wind (kt)		
1973 March	Max	Min	Ave	Precip	Snow Fall	Snow on Ground	Type + Hours	Dir.	Speed	Peak Gust
1	32	18	25	.02			ZL3,F12	ESE	8	21
2	39	32	36				F6	SSW	11	27
3	41	23	32					W	10	30
4	46	26	36					SE	11	23
5	33	29	31	.07	.25		S12	SE	14	24
6	34	31	32	.42	2.0	1	S24,F6	ESE	8	
7	34	26	30	.08	.25	2	S18	NW	15	27
8	34	14	24			2		VAR	7	22
9	37	22	30			1		SSE	16	34
10	48	27	38			.5		S	11	37
11	38	23	30	.01			L-3	NNE	8	
12	38	23	30	.18			L-12,ZL3	SSE	6	
13	40	32	36				F6	NNE	9	25
14	32	27	30	.02			ZL6	N	20	38
15	29	21	25					NNW	13	28
16	34	19	26					NNW	6	
17	34	21	28					SE	9	22
18	29	24	26	.03	.25	.3	S6	ESE	15	26
19	32	27	29	.05	1.0	1	S12	E	7	
20	35	28	32				[illegible]6	SSE	9	20
21	46	32	39					SSE	17	34
22	47	35	41					SE	15	28
23	44	35	40	.04			R6,F12	ESE	9	
24	46	31	38	.04			R12,F12	N	6	
25	50	28	39					SSE	4	
26	57	33	45					S	13	36
27	43	24	34					W	14	32
28	30	12	21					NW	12	26
29	34	18	26					N	4	
30	43	23	33					SSE	6	25
31	51	28	40					E	7	
TOTALS	57 max	12 min	32 ave	.96	3.8	2 max		SE & NNW	10 ave	38 max

Date	Temperature (°F)			Precipitation(in.)				Wind (kt)		
1973 April	Max	Min	Ave	Precip	Snow Fall	Snow on Ground	Type + Hours	Dir.	Speed	Peak Gust
1	55	30	42				F6	NNE	8	24
2	51	26	38					N	13	31
3	49	24	36					N	13	33
4	54	25	40					SW	9	25
5	52	29	40					WNW	14	37
6	33	21	27					N	14	26
7	28	20	24	.01	T		S6	N	13	26
8	37	19	28					NNE	11	38
9	36	17	26					N	10	26
10	46	12	29					WSW	8	29
11	47	22	34					N	14	35
12	52	17	34					S	5	21
13	67	27	47					S	17	34
14	69	17	43					NW	16	32
15	36	12	24					NNW	14	28
16	48	10	29					WNW	9	24
17	62	35	48					ENE	14	30
18	54	35	44	.09			R18	NE	13	34
19	66	52	59	.03			L-3,R6	ESE	20	45
20	62	43	52	.41			L-3,R6,F6	E	18	44
21	49	20	34	.04	.5		S18	WNW	14	31
22	30	18	24	.01		.5	L-3	WNW	15	27
23	35	27	31				F6	NNW	6	
24	46	30	38				F6	VAR.	7	
25	49	29	39	.01	.1		S6	NE	7	20
26	48	24	36					NNW	10	25
27	48	19	34					N	5	24
28	52	26	39					E	12	32
29	49	32	40					ENE	10	24
30	54	24	39					NNE	14	26
TOTALS	69 max	10 min	37 ave	.60	.6	.5 max		N	11 ave	45 max

Table BVI. Station: Grand Forks, N.D.

1972 Date November	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snowfall	Snow on ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	31	20	26	T	T	2	F10	S	10	24
2	34	24	29			2	F10	NW	9	24
3	42	33	38	T		1	R1	WNW	9	21
4	36	33	34			1		NW+SE	5	1[illegible]
5	44	33	38	T		T	F20, L-10	SE	9	20
6	38	25	32	.02	1	T	F11, L-5, R2, S-7	NW	17	32
7	27	22	24	T	T	T	S-4	NW	10	22
8	32	25	28	T	T	T	F4	SE	6	20
9	32	28	30	T		T	F11, ZL-8	NW	6	13
10	32	27	30				F9	NW+SSE	7	20
11	31	27	29					NNW	9	18
12	27	15	21					N	7	18
13	24	13	18					N	6	14
14	26	9	18					NW+SE	4	12
15	30	16	23					SSE	13	30
16	30	25	28	T	T		S-10	NW	7	18
17	28	22	25	T	T	T	SW1, S-7	NW	4	12
18	34	22	28	.01	.1	1	SW1, S-9	ESE	4	12
19	32	24	28	T	T	1	F4, S-2	N+SE	6	15
20	30	17	24	T	T	T	F2, S-2	N	4	17
21	21	18	20	T	T	1	S-3	NNW+S	4	15
22	38	20	29			T		SSW	14	32
23	50	26	38					SSW	9	21
24	47	27	37					W	6	17
25	35	22	28	T	T			NW	16	32
26	29	22	26	.04	1.4		S-7, BS1	SSE	5	32
27	26	9	18	T	T	1	S-14, BS2	N	12	38
28	18	2	10	.01	T	1	S-5	SSW+NW	5	14
29	31	-2	14			1		SSW	13	26
30	30	15	22	T	1	1	S-5, F5, SW2	NW	7	24
TOTALS	50 Max	-2 Min	26 Ave	.08	1.5	2		NNW	8 Ave	38 Max

1972 Date December	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snowfall	Snow on ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	16	-3	6	.02	1	2	S-6, F6, BS2	N	8	28
2	5	-11	-3			2		NNW	8	18
3	2	-16	-7			[illegible]		W	8	20
4	4	-13	-4	T	T	1	S-4	NW	5	14
5	1	-11	-5	T	T	1		NW	9	21
6	-5	-19	-12			1		W	8	20
7	-1	-18	-10			1		WNW	5	13
8	-4	-13	-8	.03	.3	1	S-10	W	6	16
9	1	-15	-7			1		SSW	5	12
10	3	-17	-7			1		SW	9	20
11	11	-7	2			1		SSE	10	23
12	9	2	6			1		WNW	9	17
13	10	-7	2	T	T	1		W	6	17
14	10	-7	2			1		S	10	29
15	4	-8	-2	T	T	1	IC1	NW	10	20
16	7	-15	-4			1		S	10	34
17	34	9	22			1		S+N	14	38
18	26	9	18	.05	T	1	S-3, IC5, ZR3, IP2, F11	NNW	7	31
19	20	7	14	T	T	1		S+W	8	24
20	23	18	20	T	T	1	S-2, F9, IC4, ZL1	NNW+SE	12	29
21	23	6	14			1		S	12	32
22	26	16	21	T	T	1	F10, ZL2	N	10	23
23	16	-4	6	T	T	1	S-7, F8, ZL5	N	13	28
24	17	-4	6	T	T	1	S-2, F3, IC2, ZR4, IP2	S	9	24
25	17	-2	8	T	T	1	S-12, F6, IC1	NNW	10	29
26	37	1	19	T	T	2	F4, IC1	SSW	14	29
27	37	12	24			2	F6	NW	8	29
28	32	23	28			2	F11	E	8	21
29	28	22	25	.25	4.3	2	S-20, IC2, BS3, ZL2	NNE	16	29
30	22	7	14	.18	2.3	7	S-24, BS22, ZL3	N	25	45
31	9	1	5	.03	.6	9	S-17, BS14, IC5	NNW	18	37
TOTALS	37 Max	-19 Min	6 Ave	.56	8.5	9 Max		NNW+S	10 Ave	45 Max

Table BVI (cont'd).

1973 Date	Temperature (°F)			Precipitation (in.)				Wind (kt)		
January	Max	Min	Ave	Precip	Snowfall	Snow on ground	Type + Hours	Dir.	Speed	Peak Gust
1	21	4	12	.01	.1	9	S-7	WNW	8	22
2	25	10	18	T	T	9	IC1	S	15	31
3	25	-1	12	.04	.6	9	S-8, BS12, IC1	NW	17	32
4	-3	-15	-9	T	T	9	S-3, IC4	NW	7	20
5	-14	-25	-20	T	T	9	IC5		Calm	6
6	-11	-25	-18	T	T	9	S-2, F1, IC4	S	2	10
7	-12	-26	-19	T	T	9	IC1		Calm	7
8	-6	-26	-16	T	T	9		W	5	17
9	1	-10	-4			9		W	10	22
10	11	-3	4	.01	.3	9	S-6, BS1	WNW	12	36
11	15	1	8			8		W	8	21
12	28	5	16			8		S+W	9	23
13	31	7	19	T	T	8	S-2, IP1	SSW+WNW	5	16
14	34	22	28			7		WNW	14	43
15	36	16	26			3		SSW	12	33
16	37	21	29			2		S	4	14
17	25	15	20	T		2	F20	N	2	12
18	27	5	16	T	T	2	S-1, F8	N	12	26
19	9	0	4			2		N	6	15
20	15	-2	6			2		SSE	7	20
21	24	14	19	.03	.4	2	S-7, F13, ZL4	S	10	24
22	35	9	22	.01	.2	3	S-2, F3, BS3, BD5	NNW	15	24
23	35	9	22			3		S+W	9	24
24	42	25	34			3		W	9	24
25	44	25	34			1		SSW	6	21
26	31	19	25	T	T	1	S-9, IC5, BS6, F4	N	17	39
27	21	13	17	T	T	1	S-2, IC5, BS6, BD6	N	20	39
28	24	6	15			1		S	8	16
29	24	12	18			1		S	6	20
30	26	10	18	T	T	1		E	5	16
31	30	22	26	T	T	1	ZL4, F18	SSE	10	20
TOTALS	44 Max	-26 Min	12 Ave	.09	1.4	9 Max		N+SSW	9 Ave	43 Max

1973 Date	Temperature (°F)			Precipitation (in.)				Wind (kt)		
February	Max	Min	Ave	Precip	Snowfall	Snow on ground	Type + Hours	Dir.	Speed	Peak Gust
1	30	16	23	T	T	1	F18, ZL1	N	9	23
2	37	16	26			1	F2	S	6	14
3	34	21	28			1		NW	5	16
4	26	13	20	T	T	1	S-4, SW4, F5	N	12	24
5	34	12	23	T	.1	1	S-3, BD2	E	12	36
6	13	2	8	T	T	1	S-1	NW	10	23
7	15	3	9			1		WNW	8	21
8	23	0	12	T	T	1		WSW	5	15
9	15	0	8	T	T	1	SW2	N	7	21
10	21	-3	9			1	BD5	SSE	13	34
11	31	16	24			1	F3	SSE	14	30
12	31	16	24	T	T	1	F21, ZL9	N+S	8	23
13	14	-3	6	.06	.9	1	S-11, F3, IC2, BS21, BD13	N	24	40
14	1	-8	-4			1	BS19, BD2	N	18	30
15	2	-10	-4	T	T	1	S-1, BS8, BD1, IC5	N	10	23
16	12	-14	-1			1	BS1, BD13	S	16	42
17	25	9	17			1		S	9	25
18	39	13	26			1	F7	S	13	28
19	24	7	16	T	T	T	SW6, F1	N	13	29
20	25	4	14	.01	.1	T	S-5, BS11, BD7	N	15	31
21	33	-3	15			T	BD1	SSW	13	30
22	43	25	34			T		WNW	10	27
23	25	17	21			T		NNE	10	21
24	26	12	19			T		NE	7	15
25	32	18	25			T		NE	4	10
26	31	23	27	T	.03	T	S-9, F4, ZL2	SSE	12	27
27	24	17	20	T	T	1	IC7, ZL1, F16	N	8	22
28	38	25	32	T	T	1	ZL3, L-1, F24	S+N	7	28
TOTALS	43 Max	-14 Min	17 Ave	.07	1.1	1 Max		NNE+SSE	10 Ave	42 Max

Table BVI (cont'd). Station: Grand Forks, N.D.

1973 Date	Temperature (°F)			Precipitation (in.)				Wind (kt)		
March	Max	Min	Ave	Precip	Snowfall	Snow on ground	Type + Hours	Dir.	Speed	Peak Gust
1	34	24	29	T		T	F20, ZL9	N+SSE	7	24
2	37	32	34			T	F21	S	16	29
3	44	28	36			T		W	12	28
4	45	26	36			T		SE	7	21
5	36	32	34	T	T	T	S-2, L-1	SE	10	21
6	36	33	34	.12	1.6	1	S-11, F21, L7, R1	ESE	7	14
7	38	33	36	.02	.2	T	S-7, F10, R3	NW	12	28
8	34	26	30	T	T	T		N	8	24
9	40	29	34			T	F6	SSE	17	38
10	49	34	42	T		T	L-1, F19	S	12	33
11	42	32	37				F15	N	9	23
12	40	26	33	.12	T		RW1, R6, L-1, F10	SSE	5	18
13	42	34	38	.02			F22,	NNE	8	22
14	37	34	36	.76	.9		S-8, F20, R4, L-3, RW1, IP5, SW1	N	20	32
15	34	29	32	T	T	1	SW3	NNW	15	37
16	35	25	30			T		N	8	17
17	37	24	30			T		E	5	14
18	34	29	32	T	T		SW1	ESE	10	21
19	39	33	36	T	T		SW2	ESE	5	16
20	43	32	38				F2	SE	5	14
21	52	32	42					SSE	15	36
22	50	34	42					SSE	14	33
23	49	40	44	T			F10, R1	SW+N	7	18
24	45	36	40	T			L-1, F19	N	8	20
25	54	32	43					N	2	10
26	59	30	44					S	12	32
27	48	33	40					SSE+W	14	29
28	31	22	26	T	T		SW1	N	9	21
29	33	22	28					N	4	18
30	47	23	35					S	2	14
31	56	28	42					NE	7	20
TOTALS	59 Max	22 Min	36 Ave	1.04	2.7	1 Max		N+SSE	9 Ave	38 Max

1973 Date	Temperature (°F)			Precipitation (in.)				Wind (kt)		
April	Max	Min	Ave	Precip	Snowfall	Snow on ground	Type + Hours	Dir.	Speed	Peak Gust
1	56	30	43					N	12	31
2	54	32	43					N	16	39
3	52	33	42					N	18	42
4	53	29	41					S+N	8	29
5	55	34	44					WNW	14	36
6	38	28	33					N	15	30
7	37	29	33	T	T		S-3	N	15	28
8	42	23	32					NNE	9	25
9	40	18	29					N	10	30
10	47	20	34					WNW	6	21
11	50	31	40					S	16	40
12	51	23	37					NNW+SSE	5	17
13	66	31	48					S	17	39
14	75	31	53					S	17	40
15	38	23	30	T	T	T	S-2, SW1	NNW	12	26
16	51	21	36					WNW	7	29
17	70	31	50					NE	5	14
18	72	38	55	.09			RW4	N	9	38
19	65	54	60	.08			RW4, F8	ESE	17	40
20	66	47	56	.17			R2	SE	17	56
21	52	34	43	T	T		RW2, SW1	W	16	33
22	35	29	32	.03	.7	1	SW2, S-2	NW	9	23
23	36	29	32					N	4	13
24	50	27	38					N	5	21
25	51	28	40					N	5	16
26	51	32	42					NNW	10	29
27	51	24	38					N	6	23
28	55	12	34					ESE	8	23
29	53	38	46	T			RW1	ENE	8	20
30	59	34	46					N	12	26
TOTALS	75 Max	12 Min	41 Ave	.37	.7	1 Max		N	12 Ave	56 Max

Table BVII. Station: Minot AFB, N.D.

Date 1972 November	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	38	18	28			2		SE+SW	3	14
2	23	15	19			1	F15	SE	5	20
3	37	21	29			1		WNW	5	21
4	34	32	33			T	F7	SE	7	22
5	35	32	34	T		T	L-4,F20,R-1	ESE+N	8	9
6	32	25	28	T	T	T	ZL-4,S-5,F3	NNW	7	18
7	26	22	24	T	T	T	S--4,F1	SW	9	22
8	28	20	24	T	T	T	F5	WSW	6	21
9	33	27	30	.02		T	ZL-11,F15	Var	2	13
10	32	19	26	.01		0	ZL-1,F7	NW SE	7	21
11	29	22	26	T			IP2,S-4	ESE+NNE	4	12
12	25	20	22	T	T	T	S-16	S	5	15
13	23	14	18	T	.1	T	S-13	SE	7	15
14	25	12	18			0		SE	13	21
15	27	16	22					SE+NW	6	18
16	30	18	24	T	.1		S-9	NW	5	16
17	27	13	20	T	T		S-8	Var	2	10
18	31	9	20	T	T		S-10	SSW	2	10
19	34	24	30						CALM	8
20	30	25	28	.02	.2		S-13	Var	2	10
21	26	20	23	.01	.1	T	S-14,F6	ENE+SE	5	14
22	38	24	31			T		SW	5	14
23	48	19	34					SW	9	27
24	43	32	38	T	T		R-1	WNW	21	36
25	33	19	26					WNW	17	33
26	33	20	22	.18	3.9	4	S-18,BS5	NW	10	32
27	32	7	20	.04	.7	4	S-10	NW	7	27
28	13	-7	3	T	.1	4	S-7,IC 5	NW	7	22
29	33	-4	14	T	T	4	S-2	WNW	14	37
30	26	17	22	.08	.7	4	SW-4,S-8,F1	SE	6	34
TOTALS	48 max	-7 min	24 ave	.36	5.9	4 max		NW & SE	7 ave	37 max

Date 1972 December	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	15	0	8	.08	1.4	5	S-10,BS3,IC 3	N+ENE	7	28
2	3	-13	-5	T	T	4	S-1	NW	10	24
3	-5	-18	-12			4		W	7	14
4	-7	-19	-13			3		W	7	15
5	-10	-21	-16			3	BS6	WNW	10	27
6	-10	-27	-18			3		W	6	16
7	-13	-23	-18			2		WNW	7	15
8	-13	-25	-19			2		WNW	5	6
9	-7	-24	-16			2		WSW	4	10
10	3	-20	-8			2		W	8	18
11	16	-4	6	T	T	2	S-1	W	8	21
12	8	-5	2	T	T	2	S-1	NW	7	21
13	4	-10	-3	.10	.1	2	S-1,IC 3	W+SSW	5	13
14	14	-7	4	T	T	2	S-2,IC 1	SW+NW	7	24
15	4	-13	-4	T	T	2	IC 3	NW	7	24
16	17	-15	1			2		SE	14	39
17	35	13	24			1		W+NNE	7	36
18	34	9	22	.03		1	F 6,ZR-3	ESE+NW	9	35
19	26	2	14	.08	.3	1	S-2,ZR-2,IP-1,BS1	SE	10	27
20	22	9	15	T	T	1	GF1,F3,S-3	NW	12	27
21	38	4	21	T		1	ZR-1,R-1	SSE+SW	12	37
22	35	16	26	T	T	1	F17,ZL-3,S-1	NNE	5	16
23	15	0	8	.01	.1	1	F 2,ZL-2,IC 4	NW+ESE	9	25
24	28	5	16	T		1	ZL-1	SE+NW	9	23
25	20	10	15	T	T	1	S-11,IC 1	NW+SW	10	21
26	41	21	31			1		W	14	28
27	36	21	28			1		NW	7	27
28	28	21	24	T	T	1	F6,S-5	E	16	36
29	23	1	12	.12	2.0	3	ZL-1,S-24,F1,BS7,IC3	NNE	17	31
30	7	-1	3	.02	[illegible]	3	IC 11,S 13, BS4	N	17	27
31	11	-8	2	T	T	3	IC2,S-1	NW	17	28
TOTALS	41 max	-27 min	5 ave	.44	4.3	5 max		WNW & SE	9 ave	39 max

Table BVII (cont'd). Station: Minot AFB, N.D.

Date 1973 January	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	19	11	15	T	T	3	S-5,IC 4	WNW	10	20
2	36	1	18	T	T	3	S-1	WNW+SW	16	36
3	0	-9	-4	T	T	3	BS 4,SW-3,S-1	NW	20	38
4	-7	-14	-10	T	T	3	IC 1,S-7	NW	9	22
5	-8	-24	-16	T	T	3	IC 3,SW-3		CALM	7
6	-10	-23	-16	T	T	3	S-3,IC 10		CALM	8
7	-10	-25	-18	T	T	3	IC 13		CALM	6
8	-5	-25	-15	T	T	3	IC 6	W	5	13
9	3	-13	-5			3		NW	14	25
10	11	0	6	T	T	3	BS 3,S-3,SW-2	NW	14	30
11	18	4	11	T	T	3	S-2, IC 3	SW+NW	7	14
12	32	16	24			2		SW	9	23
13	36	24	30	.07		2	RW-and R-1	SSW	6	23
14	36	18	27			2		WNW	15	36
15	43	32	38			2		SW	10	25
16	42	33	38			2		WSW	7	16
17	38	28	33			2		NW+SE	5	25
18	32	15	24	T	T	1	S-3, F3, ZL-1	NW	8	25
19	20	17	18	T	T	T	S-8,F17,ZL-9	SE	7	16
20	28	16	22	.06	1.0	1	S-7	S	6	24
21	32	12	22			1		SSW	7	30
22	29	13	21			1		NW+S	10	29
23	41	23	32			1		WNW	12	30
24	46	33	40			T		W	6	21
25	43	27	35			T			CALM	9
26	34	18	26	T	T	T	F3,S-5	NW	13	25
27	22	8	15			T		NW	10	23
28	24	6	15			T		SSW	6	21
29	25	12	18			T		Var	3	12
30	29	11	20			T		ESE	7	20
31	40	13	26			T		SW+SE	4	14
TOTALS	46 max	-25 min	16 ave	.13	1.0	3 max		NW	8 ave	38 max

Date 1973 February	Temperature (°F) Max	Min	Ave	Precipitation(in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	28	18	23			0		NW	5	15
2	41	20	30					WSW	5	14
3	44	25	34					SW	2	13
4	26	21	24	T	T	T	S-1	NE+SE	5	14
5	32	-1	16	.02	.5	T	S-13,BS 5	WNW+SE	16	40
6	11	-6	2			T		WNW	13	29
7	13	3	8	.01	.2	T	S-and SW-4	WNW	10	25
8	27	-2	12			T		W	7	18
9	11	1	6	T	T	T	IC6, S-3	NW+E	8	18
10	16	-1	8	T	T	T	S-3,IC 3, SW-4	SE	14	30
11	24	6	15			T		NW+E	6	17
12	21	11	16	.09	1.8	1	S-22,F14,IC 1	NNW	7	18
13	11	-13	1	.03	.6	3	S-10,IC 8, BS15	NNW	13	24
14	-2	-20	-11	T	T	3	IC 2,SW-1	N	6	12
15	-5	-19	-12	T	T	2	IC 1	ESE	7	14
16	27	-14	6			2	BS 3, BD 1, F2	S	14	32
17	35	14	24			2	F 4	SW+NW	6	15
18	39	20	30			1		SW	13	33
19	30	15	22	.01	.2	T	SW-8	NW	8	30
20	31	7	19	.01	.2	T	SW-3,S-4	NW	13	32
21	44	2	23			T		WSW	13	31
22	48	28	38			T		W	8	21
23	29	15	22			0		WSW	13	24
24	25	12	18					SE	9	17
25	31	16	24					SE	10	23
26	40	25	32	T			ZR-2,ZL-3,L-1,F1	NW+S	10	23
27	27	19	23	T	T	T	ZL-10,S-10,F16	NNE+ESE	10	24
28	29	25	27			T	F24	Var	2	12
TOTALS	48 max	-20 min	17 ave	.17	3.5	3 max		NW	9 ave	40 max

Table BVII (cont'd).

Date 1973 March	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	36	27	32			0	F 13	SW	6	20
2	50	29	40					SW	7	25
3	47	25	36					Var	2	20
4	50	23	36					SSE	10	35
5	39	31	35	.02	.2	T	S-2,F4	SSW	9	21
6	34	30	32	.19	1.9	1	S-23,F 14,R-1	NE	4	15
7	33	27	30	T	T	2	F7,S-2	NW	8	17
8	32	26	29	T	T	T	S-5	NW	7	16
9	52	27	40			T		SE	15	39
10	48	31	39			0		SSW+NW	7	35
11	43	26	34				F 9		CALM	9
12	44	25	34					Var	2	10
13	41	24	32				F 14		CALM	17
14	41	29	35	T	T		S-2,R-1,F1	NNE	13	35
15	32	21	26	T	T		SW 3	Var	2	17
16	44	19	32					Var	2	14
17	45	24	34					SSE	16	32
18	36	28	32					ESE	10	27
19	43	20	32						CALM	10
20	44	20	32					SE	12	27
21	58	31	44					SE	20	40
22	50	34	42	T			R-4,L-1	NW	12	24
23	41	35	38	.07	T		F24,R-7,L-13,S-2	NE	8	16
24	50	27	38				F1	N	4	15
25	56	25	40					W+S	5	17
26	68	33	50					SSW	12	30
27	40	26	33					NW	14	33
28	35	17	26	T	T	0	SW-1	NW	7	21
29	40	15	28						CALM	8
30	50	21	36					SSE	7	23
31	47	30	38					ESE	5	16
TOTALS	68 max	15 min	35 ave	.28	2.1	2 max		SSE + NW	7 ave	40 max

Date 1973 April	Temperature (°F) Max	Min	Ave	Precipitation (in.) Precip	Snow Fall	Snow on Ground	Type + Hours	Wind (kt) Dir.	Speed	Peak Gust
1	54	25	40			0		NW	4	14
2	53	30	42					NW	8	25
3	53	26	40					NW	7	23
4	63	21	42					SW	8	28
5	49	30	40	T			RW-1	NW	7	23
6	39	24	32	T	T	0	S-1	NNE	9	23
7	31	20	26	T	T	T	S-12	N	7	18
8	34	19	26	T	T		SW-1	NE	6	21
9	37	10	24					NW	4	15
10	48	15	32					SW	5	20
11	55	30	42					NW+NE	9	21
12	69	20	42					S	8	25
13	79	42	60					S	14	37
14	56	32	44					NW	14	31
15	42	26	34					NW	9	21
16	62	13	38					Var	4	24
17	68	31	50					NW+SE	5	22
18	65	39	52	.01			RW-4, TRW-1	NW+NNE	10	32
19	70	46	58	.34			RW-5	NNE+SE	20	36
20	59	45	52	.40			RW-6, TRW-1, A1, R-1	NE	15	45
21	43	29	36	.02	T		L-7, R-1, F4, S-7	NW	15	29
22	36	27	32	T	T		S-1, SW-1	NW	8	23
23	48	30	39					SW	8	18
24	49	33	41	.02	.4	T	SW-2, R-2, L-1	Var	2	13
25	52	35	44	.07	T	0	RW-4, SW-1	NW	4	22
26	47	28	38				F5		CALM	
27	55	26	40					SE	8	30
28	43	37	40	.22	1.1		RW-4, SW-7	SE	15	32
29	43	33	38	.24	2.0	1	RW-1, R-1, S-3, F10	E	6	20
30	54	33	44					W	6	18
TOTALS	79 max	10 min	40 ave	1.32	3.5	max		NW+SE	8 ave	45 max

Table BVIII. Comparison of drifting or blowing snow, freezing snow or freezing drizzle and snow storms, 1972-1973.

Date	Nekoma, N.D.			Grand Forks, N.D.			Minot, N.D.		
Nov. 1972	Storm Type+	Duration (hr.)*	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)
1									
2									
3									
4									
5	S	<6	0.01						
6	S	6 to 12	0.02	S	7	T	ZL,S	4,6	T
7				S	4	T	S	3	T
8	S	6 to 12	0.02						
9				ZL	8	T	ZL	11	0.02
10	S						ZL	1	0.01
11	S						IP,S	2,4	T
12	S	<6	0.01				S	16Con't	
13	S						S	13	T
14									
15									
16	S	<6,Con't	0.01	S	10	T	S	9	T
17	S	12to18	0.03	SW,S	1,7	T	S	8	T
18	S	6to12,Con't	0.02	SW,S	1,9	0.01	S	10	T
19	S	12to18,Con't	0.04	S	2	T			
20	S	6to12,Con't	0.02	S	2	T	S	13Con't	0.02
21	S	18to24	0.04	S	3	T	S	14	0.01
22	S	6to12	0.02						
23									
24	S	<6	0.01						
25									
26	S	Con't	Con't	BS,S	1,7	Con't	S,BS	18,5	0.18
27	S	24to30	0.15	BS,S	2,14	0.04	S	10Con't	0.04
28	S	<6	0.01	S	5	0.01	S	7	T
29							S	2	T
30	S	Con't	Con't	SW,S	2,5	Con't	SW,S	4,8Con't	0.08

Date	Nekoma, N.D.			Grand Forks, N.D.			Minot, N.D.		
Dec. 1972	Storm Type+	Duration (hrs.)*	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)
1	S	<6	0.02				S,BS	10,3	0.08
2				S,BS	6,2	0.02	S	1	T
3									
4				S	4	T			
5							BS	6	
6									
7									
8				S	10	0.03			
9									
10									
11							S	1	T
12							S	1	T
13							S	1	0.10
14							S	2	T
15									
16									
17									
18	S	18to24	0.04	S,ZR	3,3	0.05	ZR	3	0.03
19	S	<6	0.06				S,ZR,BS	2,2,1	0.08
20	S	12to18	0.03	S,ZL	2,1	T	S	3	T
21							ZR	1	T
22				ZL	2	Con't	ZL,S	3,1	T
23				ZL,S	5,7	T	ZL	2	0.01
24	S	<6	0.01	S,ZR	2,4	Con't	ZL	1	T
25	S	12to18	0.03	S	12	T	S	11	T
26									
27	S	Con't	Con't						
28	S	Con't	Con't				S	5	Con't
29	S	Con't	Con't	S,BS,ZL	20,3,2	Con't	S,BS,ZL	24,7,1	Con't
30	S	Con't	Con't	S,BS,ZL	24,22,3	Con't	S,BS	13,4	0.14
31	S	Con't	Con't	S,BS	17,14	0.46	S	1	T

+ Events of blowing or drifting snow and freezing rain or freezing drizzle were not observed at Nekoma.
* Only 6-hour intervals of storm duration were available at Nekoma.

Con't = Continued into next day

Table BVIII (cont'd).

Date Jan. 1973	Nekoma, N.D. Storm Type+	Duration (hr.)*	Amt. (in.) (w. Eq.)	Grand Forks, N.D. Storm Type	Duration (hr.)	Amt. (in.) (w. Eq.)	Minot, N.D. Storm Type	Duration (hr.)	Amt. (in.) (w. Eq.)
1	S	114to120	1.43	S	7	0.01	S	5	T
2	S	<6	0 03				S	1	T
3	BS	<6		S,BS	8,12	0.04	BS,SW	4,3	T
4				S	3	Con't	S	7	T
5							SW	3	T
6				S	2	T	S	3	T
7									
8									
9									
10	S	<6	0.01	S,BS	6,1	0.01	BS,SW,S	3,2,3	T
11							S	2	T
12		Con't	Con't						
13	S	30 to 36	0.07	S	2	T			
14	S	<6	0.01						
15	S	<6	0.01						
16									
17									
18	S	18 to 24	0.05	S	1	T	S,ZL	3,1	T
19							S,ZL	8,9	Con't
20							S	7	0.06
21				S,ZL	7,4	Con't			
22				S,BS	2,3	0.04			
23									
24									
25									
26	S	6 to 12	0.02	S,BS	9,6	Con't	S	5	T
27				S,BS	2,6	T			
28									
29									
30									
31				ZL	4	T			

Date Feb. 1973	Nekoma, N.D. Storm Type+	Duration (hr.)*	Amt. (in.) (w. Eq.)	Grand Forks, N.D. Storm Type	Duration (hr.)	Amt. (in.) (w. Eq.)	Minot, N.D. Storm Type	Duration (hr.)	Amt. (in.) (w. Eq.)
1				ZL	1	T			
2									
3									
4	S	<6	0.01	S,SW	4,4	T	S	1	T
5	S	18 to 24	0.06	S	3	T	S,BS	13,5	0.02
6				S	1	T			
7							S&SW	4	0.01
8									
9				SW	2	T	S	3	T
10							S,SW	3,4	T
11									
12				ZL	9	Con't	S	22	Con't
13	S	18 to 24	0.09	S,BS	11,21	0.06	S,BS	10,15	0.12
14				BS	19		SW	1	T
15				S,BS	1,8	T			
16	S	<6	0.02						
17									
18	S	6 to 12	0.02						
19	S	<6	0.01	SW	6	T	SW	8	0.01
20	S	<6	0.01	S,BS	5,11	0.01	SW,S	3,4	0.01
21									
22									
23									
24									
25									
26	S	12 to 18	0.04	S,ZL	9,2	T	ZR,ZL	2,3	T
27	S	<6	0.01	ZL	1	T	ZL/S	10	T
28	S	<6	0.02	ZL	3	T			

+ Events of blowing or drifting snow and freezing rain or freezing drizzle were not observed at Nekoma.

* Only 6-hour intervals of storm duration were available at Nekoma.

Con't = Continued into next day

Table BVIII (cont'd). Comparison of drifting or blowing snow, freezing rain or freezing drizzle and snow storms, 1972-1973.

Date	Nekoma, N.D.			Grand Forks, N.D.			Minot, N.D.		
Mar. 1973	Storm Type	Duration (hr.)*	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)
1									
2				ZL	9	T			
3									
4									
5	S	Con't	Con't	S	2	Con't	S	2 Con't	
6	S	Con't	Con't	S	11	0.12	S	23	0.21
7	S	48 to 54	0.57	S	7	0.02	S	2	T
8							S	5	T
9									
10									
11									
12									
13									
14				S,SW	8,1	Con't	S	2	T
15				SW	3	0.76	SW	3	T
16									
17									
18	S	<6	0.03	SW	1	T			
19	S	6 to 12	0.05	SW	2	T			
20									
21									
22									
23							S	2	T
24									
25									
26									
27									
28				SW	1	T	SW	1	T
29									
30									
31									

Date	Nekoma, N.D.			Grand Forks, N.D.			Minot, N.D.		
Apr. 1973	Storm Type+	Duration (hr.)*	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)	Storm Type	Duration (hr.)	Amt.(in.) (w. Eq.)
1									
2									
3									
4									
5									
6							S	1	T
7	S	<6	0.01	S	3	T	S	12	T
8							SW	1	T
9									
10									
11									
12									
13									
14									
15				S,SW	2,1	T			
16									
17									
18									
19									
20									
21	S	12 to 18	0.04	SW	1	Con't	S	7	T
22				SW,S	2,2	0.03	S&SW	1	T
23									
24							SW	2	0.15
25	S	<6	0.01				SW	1	T
26									
27									
28							SW	7	0.16
29							S	3	0.22
30									

+ Events of blowing or drifting snow and freezing rain or freezing drizzle were not observed at Nekoma.

* Only 6-hour intervals of storm duration were available at Nekoma.

Con't = Continued into next day

APPENDIX C. ESTIMATED MISSILE SITE SNOW CLEARANCE REQUIREMENTS

Location	Volume/clearance (ft^3)	Clearances/yr	Total vol/yr (yd^3)	Mass*/yr (tons)
MSR				
Limited and exclusion area roads	197,600	50	365,890	98,790
Missile field	250,000	50	462,965	125,000
Non-technical support area-parking lots	140,430	50	260,055	70,215
Non-technical support area-roads	75,000	50	138,890	37,500
Housing area roads	133,000	50	246,300	66,500
	1,592,060 ft^3 (58,965 yd^3)		1,474,100	398,005
Exclusion area fence (20 ft on each side of 50-59 ft wide double fence)	1,587,500 ft^3 (58,796 yd^3)	5	294,000	79,380
PAR				
Roads	150,440	25	139,300	37,610
Parking lots	53,630	25	49,660	13,410
	204,070 ft^3 (7558 yd^3)		188,960	51,020
REMOTE SITES				
RSL # 1	72,000	10	26,700	7,200
RSL # 2	37,000	10	13,700	3,700
RSL # 3	37,000	10	13,700	3,700
RSL # 4	23,000	10	8,500	2,300
	169,000 ft^3 (6,260 yd^3)		62,600	16,900

* Assuming density of 20 lb/ft^3

MSR: Frequency 50 clearances/year

Section	Sta.	Length (ft)	Width (ft)	Area (ft^2)	Depth (ft)	Volume (ft^3)
Tactical road (BC-45,46,47,48)	00+00-22+50	2250	32	72,000	0.5	36,000
	22+50-55+30	3280	18	59,040	0.5	29,520
	55+30-90+45.2	3545	32	113,440	0.5	56,720
Patrol road (BC-49)	100+00-109+59	959	18	17,262	1	17,262
	109+59-112+00	241	18	4,338	0.5	2,169
	112+00-116+50	450	32	14,400	0.5	7,200
	116+50-119+69	319	18	5,742	-	-
Launch area access road (BC-50,68)	200+00-206+46	646	32	elevated-no accumulation		
UMB access road (BC-50,68)	300+00-302+90.98	291	32	9,312	0.5	4,656
	Parking area	70	70	4,900	0.5	2,450
	to UMB	50	32	1,600	0.5	800
MSCB access road (BC-50)	400+00-410+21.62	1021		elevated - no accumulation		
MSPP access road (BC-51)	500+00-505+00	500	32	elevated - no accumulation		
	505+00-508+00	300	32	9,600	0.5	4,800
	508+00-513+00	500	32	16,000	2	32,000
	turnaround	50	40	2,000	2	4,000
	(5 % grade to tunnel access, 17 ft deep at portal)				Total	197,577 ft^3/clearance

Non-technical support area, MSR — Frequency 2/wk, 50/yr, 6"

Parking lots (C-4, C-5)

Location	Dimensions (ft)	Area (ft^2)
3rd St	250 x 40	10,000
	160 x 60	9,600
	80 x 30	2,400
	315 x 110	34,650
	2 x 24 x 95	4,560
	2 x 24 x 70	3,360
	63 x 60	3,780
	60 x 225	13,500
	24 x (40 + 30)	1,680
	45 x 130	5,850
EM Complex	175 x 315	55,125
Adm. Bldg.	195 x 250	48,750
Ind. Bldg.	210 x 85	17,850
Ind. Bldg. (motor pool)	125 x 225	28,125
Ind. Bldg. (entrances)	100 x 50	5,000
Ind. Bldg. (loading dock)	160 x 100	16,000
Officer's Complex	165 x 125	20,625
		280,855

Roads

Location	Dimensions	Area
Ave A	3200 x 28	89,600
1st St	1300 x 28	36,400
Ave B West	500 x 24	12,000
2nd St	300 x 24	7,200
Heliport	500 x 10	(no accumulation)
Ind. Bldg.	200 x 24	4,800
		150,000

Housing Area

Roads

Location	Dimensions (ft)	Area (ft^2)
Ave J	1300 x 28	36,400
Ave A	1900 x 28	53,200
4th St	250 x 28	7,000
5th St	150 x 28	4,200
6th St	1000 x 28	28,000
7th St	350 x 28	9,800
8th St	1150 x 28	32,200
9th St	1500 x 28	42,000
10th St	1900 x 28	53,200
		266,000

PAR

Freq. 1/wk, 25/yr ave. depth 6"

Location	Dimensions (ft)	Area (ft^2)
Roads		
N-S access road	3400 x 32	108,800
E-W access road	520 x 34	17,680
Service road B, tunnel access (6% grade)	170 x 20	3,400
Patrol road	9500 x 18	171,000
	Subtotal	300,880
Parking		
Resident engineer (2)	126 x 60	7,560
	117 x 60	7,020
	2 x 20 x 24	960
Ind. Bldg (including access roads)	190 x 182	34,580
	120 x 60	7,200
	440 x 24	10,560
	27 x 80	2,160
	14 x 80	1,120
	26 x 80	2,080
Adm. Bldg.	270 x 126	34,020
	Subtotal	107,260
	TOTAL	408,140

$204,070\ ft^3 = 7558\ yd^3/wk = 188,954\ yd^3/season$

1 x/wk x 10/yr

	Length(ft)	Width(ft)	Area(ft^2)	Depth(ft)	Volume(ft^3)
RSL # 1					
Patrol road	1350	18	24,300	1	24,300
	1050	18	18,900	0.5	9,450
Service road (dip)	200	32	6,400	6	38,400
Access road	(no accumulation)				72,150
RSL # 2					
Patrol road	1300	18	23,400	0.5	11,700
Service road	800	32	25,600	1	25,600
Access road	(no accumulation)				37,300
RSL # 3					
Patrol road	1300	18	23,400	0.5	11,700
Service road	800	18	25,600	1	25,600
Access road	(no accumulation)				37,300
RSL # 4					
Patrol road	600	18	10,800	1	10,800
	1350	18	24,300	0.5	12,150
					22,950
			TOTAL		169,700 ft^3