SUSITNA HYDROELECTRIC PROJECT

SUSITNA RIVER ICE STUDY

1982-1983

TASK 4: ENVIRONMENTAL
PRELIMINARY DRAFT
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SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

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SUSITNA HYDROELECTRIC PROJECT
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1.0 INTRODUCTION

The study of ice on the Susitna River has been ongoing since the winter of 1980-1981. The documentation has been restricted to oblique aerial photography and intermittent observations by field crews. Initially, the intent was to target locations of specific ice processes such as frazil ice generation, shore ice constrictions, ice bridges, and ice jams. Much qualitative information was gathered and documented in the Ice Observations Reports (R&M 1981b, 1982d). Renewed emphasis by environmental concerns on potential modifications to the river ice regime by hydroelectric power development resulted in a more refined ice program for 1982-1983 directed towards specific problems which may be unique to the Susitna River. Staging, ice cover development in sloughs, ice jams and their relationship to sloughs, and sediment transport are among the topics discussed in this report. It is beyond the scope of the current study to mathematically analyze the specific mechanics of river ice processes, instead, the objective is to describe the phenomena based on field observations and measurements.

1.1 Background

Beginning in the winter of 1980-1981, R&M Consultants was involved in surveying over 100 river cross sections between Talkeetna and the proposed damsite at Watana (R&M 1981a, 1982c). Ice thickness data were collected in conjunction with these surveys and used to compile a profile of the Susitna River ice cover downstream of Watana. Additional historical information on ice thicknesses is available from the U.S. Geological Survey (USGS). This agency maintains several streamgaging sites on the Susitna River and most are visited during the winter to obtain under-ice discharges. Upper Susitna data records begin in 1950 for Gold Creek and 1962 for the Cantwell site. Bilello of the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) conducted a comprehensive study entitled, "A

Winter Environmental Data Survey of the Drainage Basin of the Upper Susitna River, Alaska" (1980). This report summarizes monthly ice thickness measurements from 1961 to 1967 at Talkeetna and from 1967 to 1970 near Trapper's Creek.

Information concerning other aspects of the ice regime on the Susitna is scarce. The best potential source for a variety of qualitative historical information concerning ice jams and floods are area residents, especially those employed by the Alaska Railroad. Many interviews were conducted and the resulting information was documented in the 1981 ice report (R&M 1981b). This first ice report consisted mostly of narrative chronological descriptions based on aerial observations at various sites. The report also contains most of the historical information available from the U.S. Geological Survey, the National Weather Service - River Forecast Center, and the U.S. Army, Corp of Engineers.

The ice study of 1981-1982 followed the same general guidelines. Aerial reconnaissance was conducted weekly through January and the freeze-up sequence was described in the final report (R&M 1982d). Ice thickness measurements were obtained at many of the locations surveyed in 1981 in order to assess yearly variability. Breakup was periodically observed from April 12 to May 15, and documentation was limited to information gathered on aerial overflights.

1.2 Scope of Work for 1982-1983

The Susitna River ice studies evolved considerably during the past year. Emphasis was placed on documenting site specific, ice cover induced problems identified during previous observations. These included ice jamming and flooding at the Susitna confluence with the east channel of the Chulitna River, staging effects through spawning areas, and ice jamming near the proposed upstream cofferdam at

Watana. Reaches where ice jams recur annually were investigated for morphologic changes and identification of critical factors governing ice jam formation. Collection of additional quantitative data was also required for proposed modelling efforts. These data included velocities, maximum stages at various sites, ice thicknesses, ice discharges, rates of ice cover advance, water temperatures, and locations of significant open leads. The number of observations was increased in proportion to the frequency of specific ice events and during breakup, field crews documented daily changes in the ice cover. The specific data collected during the 1982-1983 season included:

1. Locations of ice bridges
2. Rate of upstream progression of the ice cover
3. Ice discharge estimates
4. Ice cover at tributaries
5. Ice cover at aquatic habitat areas
6. Water temperature
7. Locations and size of open leads
8. Aerial photography, oblique and vertical
9. Meteorological data at specific sites
10. Ice cover processes in Devil Canyon
11. Maximum water levels
12. Ice thicknesses
13. Velocities and discharges
14. Profiles and cross sections
15. Time-lapse photography
16. Locations and effects of ice jams
17. Water table fluctuations

Meteorological data from five weather stations near the river channel are summarized in Section 3. In addition, figures are provided that illustrate the variability in air temperatures, freezing degree-days and precipitation from the upper Susitna at Denali to Talkeetna.

Section 4 considers the processes associated with ice cover development and how they relate to the 1982 Susitna River freeze-up. Breakup is described in Section 5, beginning with the initial processes of ice deterioration followed by the cause and effects of ice jams.

The subtle processes of sediment transport during freeze-up are described in Section 6, along with the more dramatic nature of ice scouring and erosion during breakup.

Section 7 discusses the environmental effects induced by ice cover development. Topics in this section include:

1. Channel morphology changes
2. Aquatic habitat modifications
3. Relationship between sloughs and ice jams
4. Damage to vegetation
5. Ice regime in side channels and sloughs
6. Flooding of islands

Photographs illustrating specific ice processes and events, have been included in order to assist those who are unfamiliar with river ice in gaining an understanding of the characteristics and effects of the Susitna River ice regime.

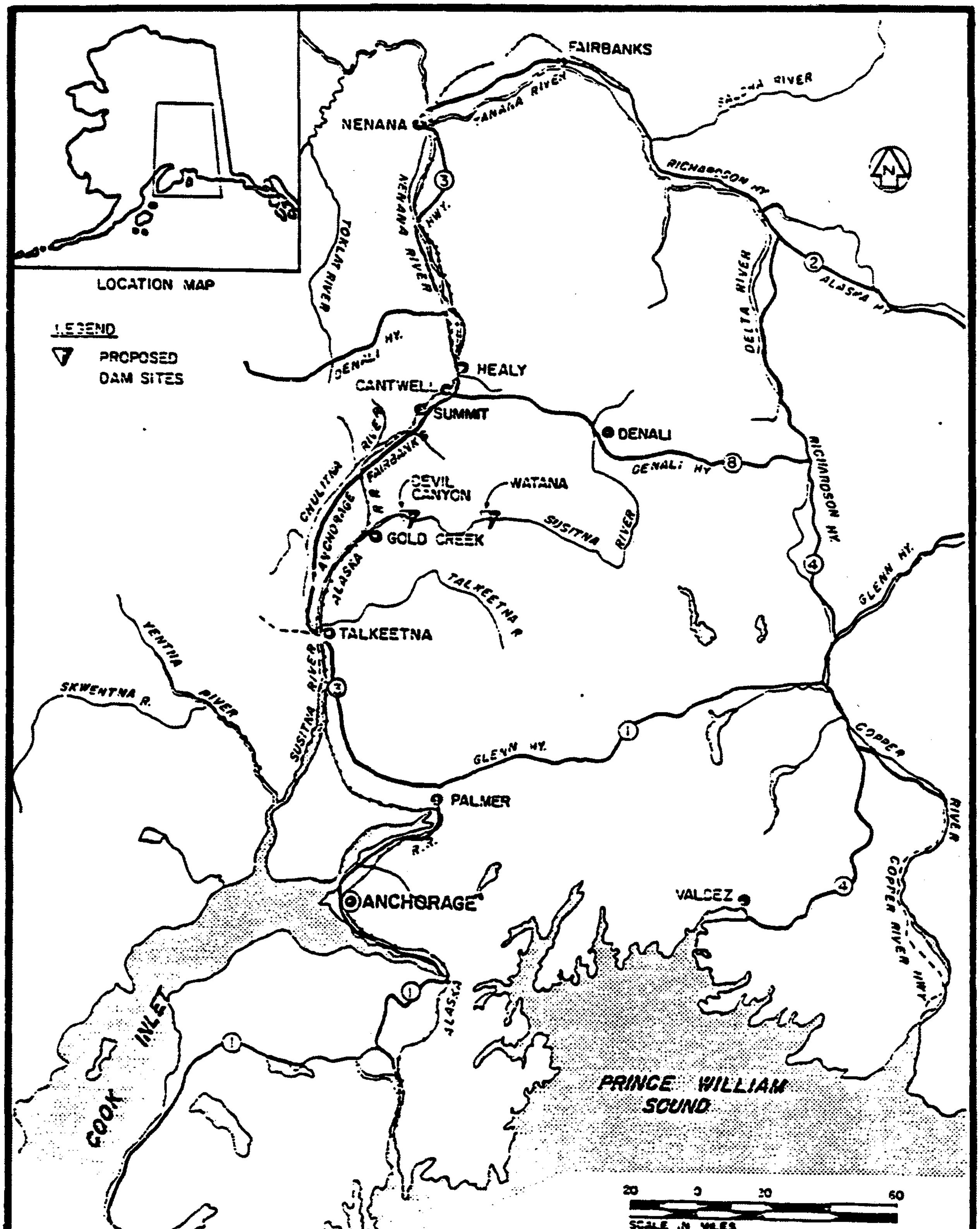
Many of the discussions in this report rely on a familiarity with certain place names and river mile locations. Table 1.1 lists those which are environmentally significant and often referred to in the test. Figure 1.1 shows the Susitna Hydroelectric Project location relative to southcentral Alaska. River mile locations have been annotated on detailed river maps included in Appendix B. Left bank and right bank in this report refer to the respective shorelines when viewed looking downstream.

TABLE 1.1

RIVER MILE LOCATIONS OF SIGNIFICANT FEATURES ON THE SUSITNA RIVER

Place	River Mile *
Devil Canyon	150.0
Portage Creek	149.0
Slough 22	144.5
Slough 21	142.0
Indian River	138.5
Gold Creek	136.5
Slough 11	136.4
Sherman	131.0
Slough 9	129.0
Slough 8	127.0
Slough 7	123.0
Curry	121.0
Lane Creek	114.0
Chase	108.0
Whiskers Creek	101.0
Chulitna/Susitna Confluence	98.5
Talkeetna	97.0
Birch Creek Slough	93.0
Sunshine/Parks Highway Bridge	84.0
Rabideux Creek	83.0
Montana Creek	77.0
Goose Creek Slough	72.0
Kashwitna Creek	61.0
Willow Creek	49.0
Deshka River	40.5
Yentna River	28.0
Susitna Station	25.5
Alexander Slough	19.0
Alexander	10.0

* Photo mosaic maps indicating river miles are included in Appendix B. Locations indicate the most upstream and or entrance.



SUSITNA HYDROELECTRIC PROJECT LOCATION MAP

Figure 1.1

2.0 SUMMARY

Frazil ice generally first appears on the Susitna River between Denali and Vee Canyon. This reach of river is commonly subjected to freezing air temperatures by mid-September. By the end of October 1983, the entire river had cooled to 0°C and frazil slush had accumulated into an ice cover that started near Cook Inlet and extended upstream to Talkeetna. The development of an ice cover on the lower river below Talkeetna required only about 14 days. This rapid ice cover progression was due primarily to the gentle gradient, low flow velocities and broad river channel common to this section. Very little staging was necessary during the ice cover advance, generally 1-2 feet upstream to approximately river mile (RM) 67 and then steadily more as the channel gradient became steeper. At Talkeetna the staging amounted to over 4 feet near the entrance to a side channel.

On November 5, 1983 an ice jam occurred at the confluence of the Chulitna River east channel and the Susitna mainstem. This initiated the ice cover progression on the Susitna upstream to Gold Creek. Staging along this reach was generally more extreme with water levels commonly increasing more than 4 feet. The leading edge reached Gold Creek by January 14, 1983 after having slowed to a progression rate of only 0.05 miles/day. This was due to a reduction in the ice discharge caused by the development of an ice cover in the upper river which effectively sealed off the air/water interface preventing frazil generation. The reach from Gold Creek to Devil Canyon took considerably longer to freeze and the processes involved were also different from those in the reaches further downstream. This area experienced extensive shore ice development and ice dams.

A time lapse camera was mounted on the south rim of Devil Canyon in order to document the formation of massive ice shelves that develop near the proposed damsite. The ice cover in this turbulent, high velocity reach, often the first to form on the entire Susitna River, was very unstable and was constantly either disintegrating or accumulating. The 8 mm movie camera provided footage that revealed valuable information concerning how an ice cover forms over rapids.

The upper river from Devil Canyon to Denali was not monitored closely during freeze-up or breakup but routine flights to Watana Camp provided much interesting qualitative information on the processes affecting this reach. Essentially, this reach develops wide shore ice by building successive layers of frazil and snow slush. The channel finally becomes so narrow that slush is entrapped and eventually freezes into a continuous ice cover.

After an inital ice cover forms, continually decreasing water levels lower the floating ice until the majority of the cover has settled on the bottom, often conforming to the channel configuration. Open leads begin developing over turbulent water. Some may gradually close again through accumulations of fine slush ice against the downstream edge of the lead. Many open leads persist all winter.

Groundwater seeping into the mainstem, side channels and sloughs usually erodes away the existing ice cover. These areas can remain ice free for most of the winter.

Breakup is generally initiated by increasing incident solar radiation, warm air temperatures, and subsequent rising water levels. The first effects are seen during April when open leads begin to enlarge and the ice cover surrounding these leads is gradually undercut by higher flows. Ice fragments collapse into the leads and drift downstream to pile up against the solid ice cover. Eventually open leads may merge, creating a long, wide channel. The small jams commonly associated with the lead enlargement process, can accumulate sufficient mass to ground on the channel bottom. This caused the first jams to form at Lane Creek and at Slough 21. Essentially, open leads continue lengthening until the river is divided between reaches of open water and large masses of accumulated ice debris. The ice jams then release in succession starting with the jam furthest upstream which, in 1983, was at Slough 21. The debris drifts with the current until encountering the next jam. The volume of drifting ice can become so massive that most ice jams are immediately swept away, further increasing the total accumulated mass.

In May of 1983 an extensive buildup of flowing ice debris was stopped near Chase by a combination of the only remaining solid ice cover, and a shallow reach of river nearly 3 miles long. The ice cover disintegrated on impact but stalled the flow long enough for the ice to pile up and ground fast. This jam held for two days and the ice debris then flowed unobstructed to Cook Inlet. Although by May 10, 1983 the entire river was essentially ice free, ice floes continued drifting downstream for several weeks as previously stranded floes were picked up by steadily increasing discharges,

The lower Susitna River downstream of Talkeetna experienced an extremely mild breakup. Observers at the Deshka River confluence and at Susitna Station thoroughly documented breakup this year. Their descriptions and data indicated that the ice cover fragmented and flowed out between May 2 and May 4. Most of the ice cover simply deteriorated while remaining shore-fast and little jamming activity took place. The only significant ice jam below the Parks Highway Bridge occurred near the confluence with Montana Creek.

This past river ice season was significantly moderated by mild temperatures and snowfall. Ice thicknesses did not reach proportions of previous years and little precipitation occurred during breakup. Much data was documented during freeze-up in 1982 and breakup in 1983 for computer modelling input but it must be recognized that they do not necessarily represent conditions in a normal year.

3.0 METEOROLOGY

Mathematical derivations of heat exchange coefficients will be required for computer simulations of river ice cover formation. Accurate and consistent measurements of meteorological parameters are essential for developing representative values for the heat gain and heat loss components of the energy exchange equation. A detailed heat exchange analysis is beyond the scope of this report. This section is limited to brief comments on the processes of surface heat exchange, definitions of the mechanisms by which they occur and identification of the meteorological parameters that are currently being monitored in the vicinity of the Susitna Hydroelectric Project.

Natural water bodies receive the most heat from solar shortwave radiation (H_s) and longwave atmospheric radiation (H_a), and lose heat to the atmosphere by longwave back radiation (H_b), evaporation heat loss (H_e), and conduction heat loss (H_c). Not all of the incoming solar and long wave radiation is absorbed. A certain percentage is reflected at the water surface and these values are generally computed based on reflectivity coefficients which are ratios of reflected radiation to incident radiation. Reflected solar radiation (H_{sr}) is usually of greater magnitude than reflected atmospheric radiation (H_{ar}), but more variable due to cloud cover, latitude, and altitude.

The net rate of heat transfer across a water surface is:

$$H = (H_s - H_{sr} + H_a - H_{ar}) - (H_b \pm H_c \pm H_e).$$

The parameters representing the absorbed radiation, combined in the parentheses on the left, are independent of the water surface temperature. The terms in the right parentheses represent the temperature dependent parameters of heat loss, (Edinger, 1974).

Values for the individual heat exchange components can be derived from the following measured meteorological variables: solar radiation, air temperature, and dew point temperature. These parameters have been monitored at several locations throughout the upper Susitna Basin for the past 3 years by R&M Consultants. In addition, a 42 year record is available from the meteorological station at the Talkeetna Airport operated by the National Weather Service. These weather stations were selected for the data summaries included in this report because they are situated close to the river and most accurately represent the climatic regime directly influencing the water surface. They are located at Denali, Watana, Devil Canyon, Sherman, and Talkeetna. Additional information about each weather station, including exact location and sensor specifications, have been published previously and is therefore not included in this report. Those readers not familiar with this aspect of the project may wish to consult the Processed Climatic Data Reports, Volumes 1-8 (R&M, 1982e) which includes a detailed description of the meteorological data collection program.

Mean maximum, mean minimum and mean daily air temperatures for each station from September 1982 through May 1983 have been summarized in Table 3.1. Mean daily air temperatures are plotted in Figure 3.1. Tables 3.2, 3.3, and 3.4 list the number of freezing degree-days per month between September and May for the existing record at each station (Talkeetna 1980-1983 only), and are graphed in Figure 3.2. Only the Watana (R&M Consultants) and Talkeetna (NWS) stations have the capability to measure precipitation on a daily basis throughout the winter months. These data have been plotted in Figure 3.3.

The meteorology within the upper Susitna Basin is highly variable at any given time between weather station sites. This is due, in part, to the movement of storm systems, the topographic variance, and the change in latitude, but mostly to the 2,400 feet difference in elevation between Denali and Talkeetna. The graphs presented in this section illustrate not only the colder daily temperatures at Denali but also their longer duration. In

October 1982, for instance, Denali had a total of approximately 370 freezing degree days (°C) while Talkeetna had only 170. This difference may be significant since the entire Susitna River downstream of Talkeetna developed an ice cover by November 1, 1982. Caution is therefore advised in using average values for the Susitna Basin since these may not be representative of any location along the river. There is also significant difference in precipitation and wind run between Watana and Talkeetna. Watana receives only a fraction of the precipitation measured at Talkeetna primarily because of orographic effects at Watana and the high concentration of storm systems from Chulitna Pass to Talkeetna. The Watana weather station is situated on a high plateau and is exposed to wind runs not common on the river.

The data summarized in the tables and figures in this section are based on published and provisional monthly meteorological summaries from each respective weather station. These have been included in Appendix B.

TABLE 3.1

METEOROLOGICAL DATA SUMMARY FROM SELECTED WEATHER STATIONS ALONG THE UPPER SUSITNA RIVER SEPTEMBER 1982 - MAY 1983

	Air Temperatures Mean Maximum (°C)	Mean Minimum (°C)	Mean Monthly (°C)	Departure from Normal (°C)	Precipitation (mm)	Departure from Normal (mm)	Depth of Snow on Ground (cm)
September 1982							
Talkeetna	11.5	4.1	7.8	0.0	190.0	76.1	0.0
Sherman	11.4	2.8	7.1	0.0	232.2	0.0	-
Devil Canyon	9.5	2.5	6.0	1.4	156.6	59.1	-
Watana	8.4	1.6	5.0	0.4	100.8	15.6	-
Denali*	-	-	3.6	-0.2	-	-	-
Basin Average	10.2	2.8	5.9	0.3	169.9	37.7	0.0
October 1982							
Talkeetna	-0.6	-9.4	-5.0	-4.9	52.2	-11.8	40.3
Sherman*	1.0	-8.0	-5.7	0.0	-	-	-
Devil Canyon	-2.6	-9.8	-6.2	-4.1	-	-	-
Watana	-3.3	-11.9	-7.6	-3.8	4.2	-6.1	-
Denali	-	-	-11.8	-6.0	-	-	-
Basin Average	-1.4	-9.8	-7.3	-3.8	28.2	-9.0	-
November 1982							
Talkeetna	-4.4	-12.6	-8.5	-0.4	42.8	-2.3	70.6
Sherman*	-4.5	-11.4	-10.0	0.0	-	-	-
Devil Canyon	-5.8	-11.9	-8.9	-1.5	-	-	-
Watana	-7.1	-14.4	-10.7	-1.4	0.2	-2.4	-
Denali*	-	-	-15.7	-5.2	-	-	-
Basin Average	-5.5	-12.6	-10.8	-1.7	21.5	-2.4	-

* Partial Record - Some values for mean daily temperatures, used to compute the mean monthly temperature, are based on linear regression analyses. See Appendix A.

TABLE 3.1 (Continued)

	Air Temperatures: Mean Maximum (°C)	Mean Minimum (°C)	Mean Monthly (°C)	Departure from Normal (°C)	Precipitation (mm)	Departure from Normal (mm)	Depth of Snow on Ground (cm)
December 1982							
Talkeetna	-3.5	-10.8	-7.2	5.6	45.4	2.3	73.1
Sherman	-4.8	-12.7	-8.7	0.0	-	-	-
Devil Canyon	-5.1	-11.3	-8.2	4.4	-	-	-
Watana	-6.9	-13.9	-10.4	4.7	7.0	2.3	-
Denali*	-9.6	-19.6	-15.4	4.8	-	-	-
Basin Average	-6.0	-13.7	-10.0	3.9	26.2	2.3	-
January 1983							
Talkeetna	-6.2	-15.4	-10.8	2.3	11.6	-24.9	80.6
Sherman*	-8.6	-17.4	-11.0	0.0	-	-	-
Devil Canyon*	-8.5	-15.4	-11.4	-1.5	-	-	93.2
Watana	-11.0	-17.4	-14.1	-1.2	2.8	1.3	26.2
Denali*	-12.1	-22.0	-17.1	-1.2	-	-	20.9
Basin Average	-9.3	-17.5	-12.9	-0.3	7.2	-11.8	55.2
February 1983							
Talkeetna	-1.7	-13.3	-7.5	2.3	11.6	-27.0	80.6
Sherman*	-9.1	-21.5	-8.0	0.0	-	-	107.9
Devil Canyon	-3.2	-11.9	-7.5	1.5	-	-	93.2
Watana	-6.5	-13.6	-10.0	-2.5	0.0	-15.2	29.0
Denali	-8.9	-19.3	-14.1	0.7	-	-	25.7
Basin Average	-5.9	-15.9	-9.4	0.4	5.8	-21.1	67.3

* Partial Record - Some values for mean daily temperatures, used to compute the mean monthly temperature, are based on linear regression analyses. See Appendix A.

TABLE 3.1 (Continued)

	Air Temperatures: Mean Maximum (°C)	Mean Minimum (°C)	Mean Monthly (°C)	Departure from Normal (°C)	Precipitation (mm)	Departure from Normal (mm)	Depth of Snow on Ground (cm)
March 1983							
Talkeetna	3.7	-10.7	-3.5	3.6	2.3	-35.3	75.6
Sherman*	6.1	-11.2	-4.2	0.0	-	-	106.8
Devil Canyon	0.7	-10.5	-4.9	-0.3	-	-	96.3
Watana	-3.3	-12.0	-7.6	-0.9	-	-	-
Denali	-5.3	-18.2	-11.8	-2.2	-	-	37.8
Basin Average	1.9	-12.5	-6.4	0.0	2.3	-35.3	78.9
April 1983							
Talkeetna	6.9	-3.1	1.9	1.4	65.0	30.7	55.4
Sherman	8.0	-4.4	1.8	0.0	68.0	0.0	-
Devil Canyon	5.6	-4.0	0.8	0.4	33.2	-	92.0
Watana	3.2	-5.4	-1.1	2.2	2.6	-	21.7
Denali	3.0	-7.6	-2.3	2.5	0.8	-	33.5
Basin Average	5.3	-4.9	0.2	1.3	33.9	-	50.7
May 1983							
Talkeetna	14.7	3.0	9.1	3.4	32.3	-3.1	0.0
Sherman	12.7	0.1	6.9	0.0	19.4	0.0	0.0
Devil Canyon	11.9	1.8	6.8	0.2	25.4	-	0.0
Watana	9.9	0.6	5.3	0.2	15.2	-	0.0
Denali	9.1	0.4	4.9	0.1	7.6	-	0.0
Basin Average	11.7	1.2	6.6	0.8	20.0	-	0.0

* Partial Record - Some values for mean daily temperatures, used to compute the mean monthly temperature, are based on linear regression analyses. See Appendix A.

TABLE 3.2

NUMBER OF FREEZING DEGREE DAYS (°C)
September 1982 - May 1983

	Monthly	Accumulated	Average Historical** Record Normal Month	Mean Monthly Air Temperature (°C)
September 1982				
Talkeetna	0	0	0	7.8
Sherman	0	0	0	7.1
Devil Canyon	0	0	5	6.0
Watana	1	1	13	5.0
Denali*	7	7	17	3.6
Basin Average	2	2	7	5.9
October 1982				
Talkeetna	172	172	72	-5.0
Sherman*	189	189	-	-5.7
Devil Canyon	200	200	95	-6.2
Watana	236	237	127	-7.6
Denali*	367	374	192	-11.8
Basin Average	233	234	122	-7.3
November 1982				
Talkeetna	258	430	191	-8.5
Sherman*	301	490	-	-10.0
Devil Canyon	256	456	222	-8.9
Watana	304	541	279	-10.7
Denali*	471	845	376	-15.7
Basin Average	318	552	267	-10.8

TABLE 3.2

NUMBER OF FREEZING DEGREE DAYS (°C)
September 1982 - May 1983
(Continued)

	Monthly	Accumulated	Average Historical** Record Normal Month	Mean Monthly Air Temperature (°C)
December 1982				
Talkeetna	230	660	407	-7.2
Sherman	274	764	-	-8.7
Devil Canyon	255	711	391	-8.2
Watana	324	865	468	-10.4
Denali*	477	1322	627	-15.4
Basin Average	312	864	473	-10.0
January 1983				
Talkeetna	336	996	311	-10.8
Sherman*	340	1104	-	-11.0
Devil Canyon*	354	1065	325	-11.4
Watana	440	1305	402	-14.1
Denali*	630	1952	531	-17.1
Basin Average	420	1284	392	-12.9
February 1983				
Talkeetna	211	1207	224	-7.5
Sherman*	225	1329	-	-8.0
Devil Canyon	212	1277	254	-7.5
Watana	281	1586	289	-10.0
Denali	395	2347	416	-14.1
Basin Average	265	1549	297	-9.4

TABLE 3.2

NUMBER OF FREEZING DEGREE DAYS (°C)
September 1982 - May 1983
(Continued)

	Monthly	Accumulated	Average Historical** Record Normal Month	Mean Monthly Air Temperature (°C)
March 1983				
Talkeetna	120	1327	107	-3.5
Sherman*	128	1455	-	-4.2
Devil Canyon	153	1430	147	-4.9
Watana	233	1819	223	-7.6
Denali	366	2713	302	-11.8
Basin Average	200	1749	195	-6.4
April 1983				
Talkeetna	15	1342	36	1.9
Sherman	21	1476	21	1.8
Devil Canyon	30	1460	75	0.8
Watana	65	1884	115	-1.1
Denali	81	2794	151	-2.3
Basin Average	42	1791	80	0.2
May 1983				
Talkeetna	0	1342	0	9.1
Sherman	0	1476	0	6.9
Devil Canyon	0	1460	0	6.8
Watana	0	1884	9	5.3
Denali	0	2794	5	4.9
Basin Average	0	1791	3	6.6

* Partial Record - Some values are based on linear regression analyses. See Appendix A.

** Period of Record:

Talkeetna	1940 - 1983, only used 1980-1983
Sherman	1982 - 1983
Devil Canyon	1980 - 1983
Watana	1980 - 1983
Denali	1980 - 1983

s5/cc5

TABLE 3.3

NUMBER OF FREEZING DEGREE DAYS (°C)
SEPTEMBER 1981 - May 1982

	Monthly	Accumulated	Mean Monthly Air Temperature (°C)
September 1981			
Talkeetna	0	0	7.3
Sherman	(No Data)		
Devil Canyon	12	12	4.4
Watana	33	33	4.0
Denali	40	40	3.2
Basin Average	21	21	4.7
October 1981			
Talkeetna	29	29	2.0
Sherman	(No Data)		
Devil Canyon	41	53	-0.4
Watana	72	105	-2.1
Denali	108	148	-2.8
Basin Average	63	84	-0.8
November 1981			
Talkeetna	205	234	-6.4
Sherman	(No Data)		
Devil Canyon	255	308	-8.3
Watana	316	421	-10.4
Denali	389	537	-12.9
Basin Average	291	375	-9.5
December 1981			
Talkeetna	367	601	-11.7
Sherman	(No Data)		
Devil Canyon	363	671	-11.6
Watana	424	845	-13.7
Denali	514	1051	-16.5
Basin Average	417	792	-13.4
January 1982			
Talkeetna	531	1132	-17.1
Sherman	(No Data)		
Devil Canyon	528	1199	-17.0
Watana	622	1467	-20.1
Denali	732	1833	-25.2
Basin Average	616	1408	-19.8

s5/cc6

TABLE 3.3

NUMBER OF FREEZING DEGREE DAYS (°C)
SEPTEMBER 1981 - May 1982
(Continued)

	Monthly	Accumulated	Mean Monthly Air Temperature (°C)
February 1982			
Talkeetna	285	1417	-9.9
Sherman	(No Data)		
Devil Canyon	344	1543	-12.1
Watana	365	1782	-13.0
Denali	525	2358	-18.7
Basin Average	380	1775	-10.7
March 1982			
Talkeetna	161	1578	-5.0
Sherman	(No Data)		
Devil Canyon	223	1766	-7.1
Watana	299	2081	-9.6
Denali	359	2717	-11.5
Basin Average	261	2035	-8.3
April 1982			
Talkeetna	46	1624	0.1
Sherman	(No Data)		
Devil Canyon	102	1868	-2.7
Watana	140	2221	-4.5
Denali	182	2899	-5.9
Basin Average	118	2153	-3.3
May 1982			
Talkeetna	0	1624	6.4
Sherman	0	-	6.4
Devil Canyon	0	1868	4.4
Watana	27	2248	2.3
Denali	15	2914	2.5
Basin Average	8.4	2164	4.4

TABLE 3.4

NUMBER OF FREEZING DEGREE DAYS (°C)
SEPTEMBER 1980 - MAY 1981

	Monthly	Accumulated	Mean Monthly Air Temperature (°C)
September 1980			
Talkeetna	0	0	7.7
Devil Canyon	1	1	3.5
Watana	4	4	3.5
Denali	4	4	4.7
Basin Average	2	2	4.9
October 1980			
Talkeetna	14	14	2.1
Devil Canyon	45	46	0.2
Watana	74	78	-2.1
Denali	102	106	-2.9
Basin Average	59	61	-0.7
November 1980			
Talkeetna	111	125	-3.5
Devil Canyon	154	279	-5.1
Watana	216	294	-7.2
Denali	269	375	-9.0
Basin Average	188	268	-6.2
December 1980			
Talkeetna	623	748	-20.1
Devil Canyon	556	835	-17.9
Watana	656	950	-21.1
Denali	890	1265	-28.3
Basin Average	681	950	-22.0

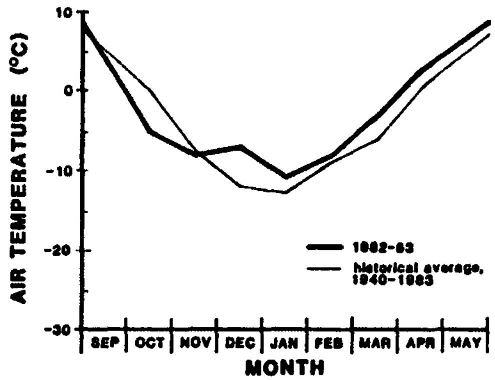
s5/cc8

TABLE 3.4

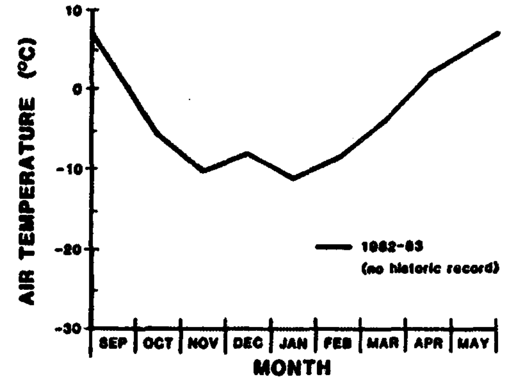
NUMBER OF FREEZING DEGREE DAYS (°C)
SEPTEMBER 1980 - MAY 1981
(Continued)

	Monthly	Accumulated	Mean Monthly Air Temperature (°C)
January 1981			
Talkeetna	66	814	-1.8
Devil Canyon	92	927	-2.5
Watana	143	1070	-4.5
Denali	181	1446	-5.5
Basin Average	121	1064	-3.6
February 1981			
Talkeetna	177	991	-6.1
Devil Canyon	205	1132	-7.3
Watana	221	1291	-7.9
Denali	328	1774	-11.8
Basin Average	233	1297	-8.3
March 1981			
Talkeetna	40	1031	-0.4
Devil Canyon	65	1197	-1.8
Watana	136	1427	-4.3
Denali	181	1955	-5.6
Basin Average	106	1403	-3.0
April 1981			
Talkeetna	48	1079	-0.1
Devil Canyon	92	1289	-1.8
Watana	141	1568	-4.3
Denali	190	2145	-6.2
Basin Average	118	1520	-3.1
May 1981			
Talkeetna	0	1079	10.0
Devil Canyon	0	1289	8.7
Watana	0	1568	7.6
Denali	0	2145	7.1
Basin Average	0	1520	8.4

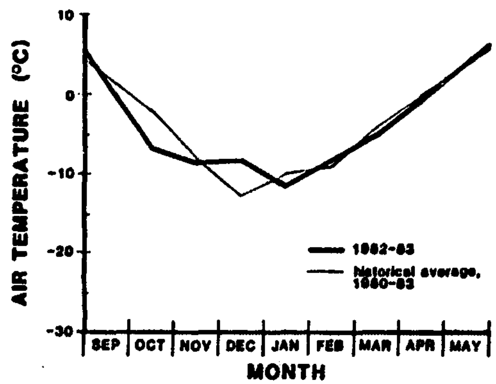
MEAN MONTHLY AIR TEMPERATURE SEPTEMBER 1982 - MAY 1983 AND HISTORIC MEAN



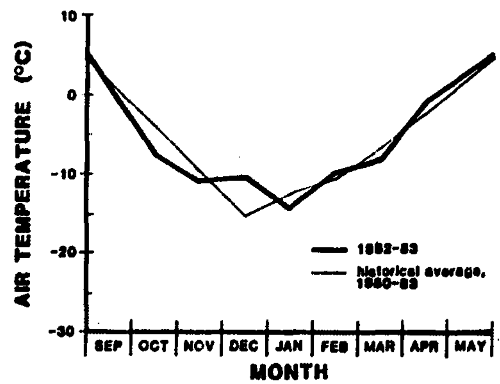
Location: Talkeetna, Alaska
Operator: National Weather Service



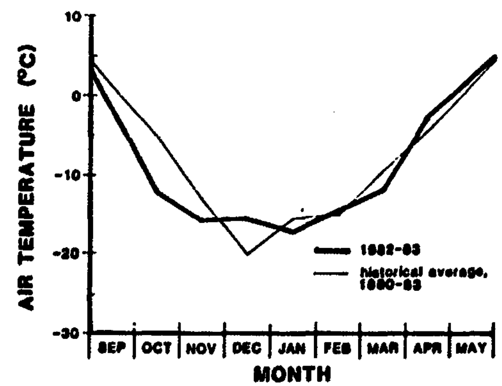
Location: Sherman Weather Station
Operator: R & M Consultants, Inc.



Location: Devil Canyon Weather Station
Operator: R & M Consultants, Inc.



Location: Watana Weather Station
Operator: R & M Consultants, Inc.



Location: Denali Weather Station
Operator: R & M Consultants, Inc.

Figure 9.1

R&M CONSULTANTS, INC.
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HARZA-EBASCO
SUSITNA JOINT VENTURE

FREEZING DEGREE DAYS MONTHLY TOTAL

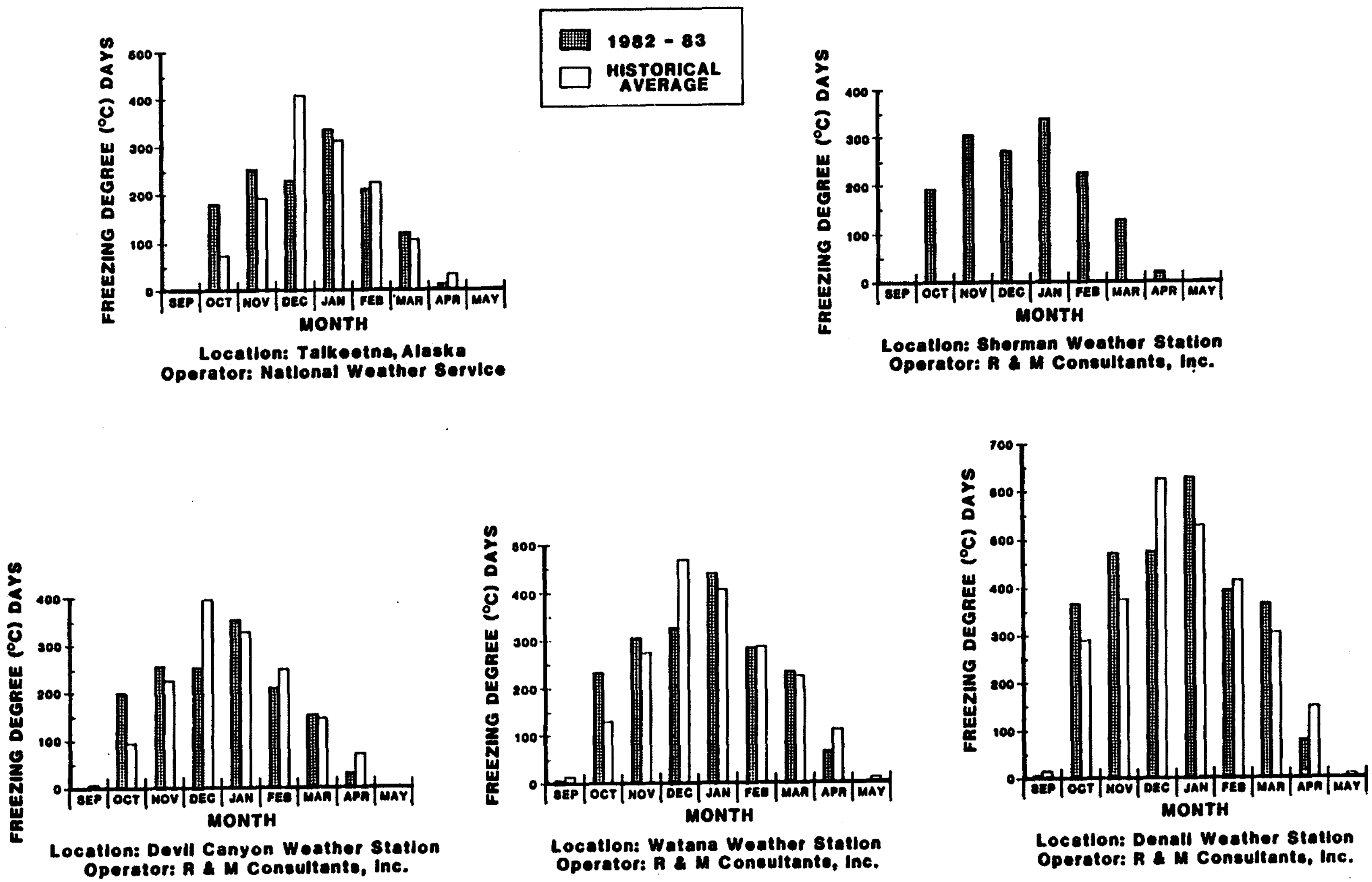

Figure 3.2

MONTHLY PRECIPITATION DATA
October 1982 - May 1983

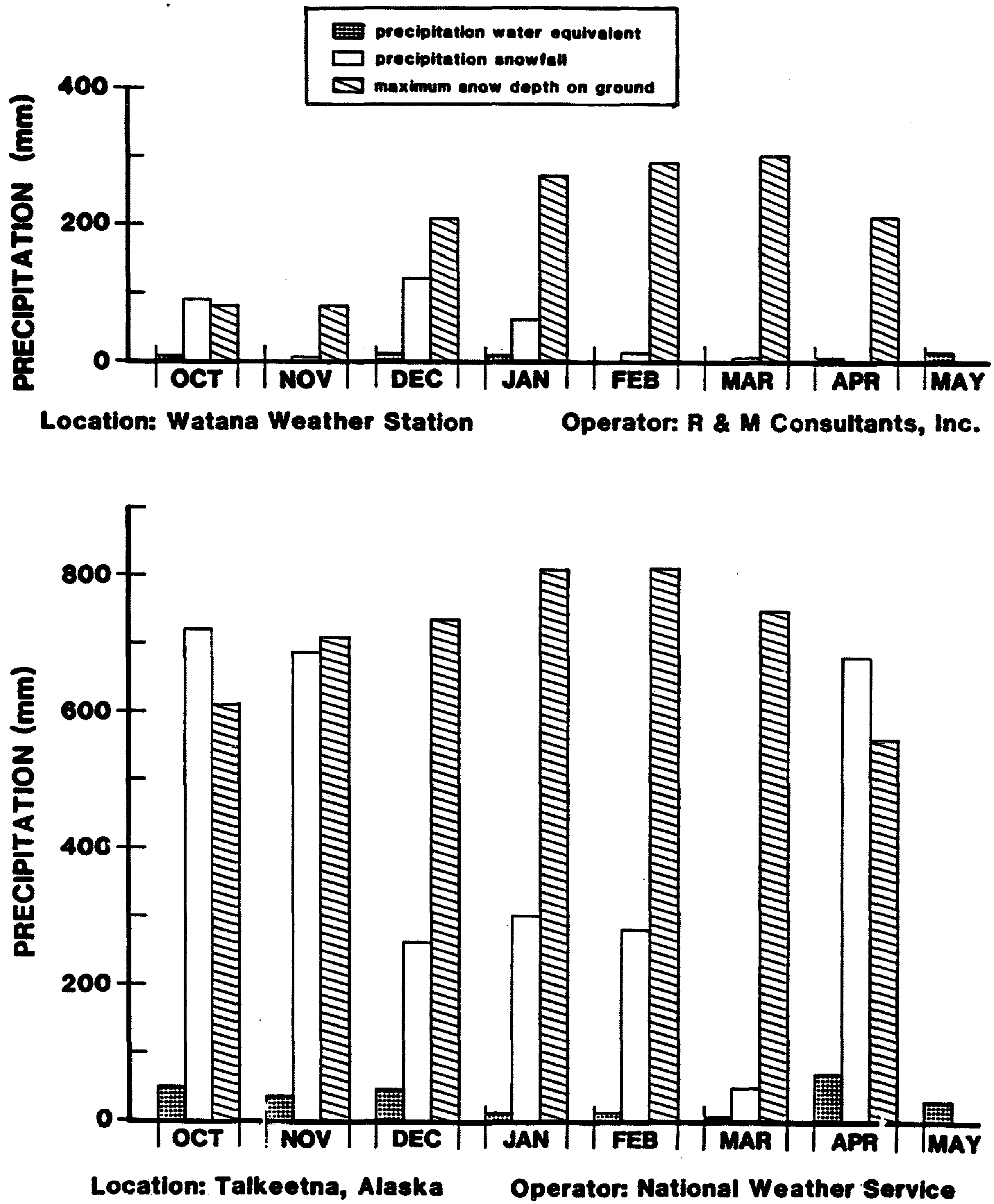

Figure 3.2

4.0 SUSITNA RIVER FREEZE-UP PROCESSES

Freeze-up processes initiated in early October, 1982 and continued through final ice cover development in March 1983. This section describes the various types of ice covers that form on the Susitna River from Cook Inlet upstream to the proposed damsite at Watana.

4.1 Definitions of Ice Terminology and Comments on Susitna River Ice

Some users of this report may not be familiar with standard terminology used in describing river ice and since a rather extensive description of ice processes on the Susitna River follows, a brief discussion on common types of ice observed on the Susitna is presented here. This is not intended to be a complete glossary of ice terms, and those interested in information on other types of ice should refer to the more definitive papers on river ice listed in Section 8 (e.g. Newbury 1968, Michel 1971, Ashton 1978, and Osterkamp 1978).

Frazil - Individual crystals of ice generally believed to form when atmospheric (cold air) and hydraulic (turbulence) conditions are suitable to maintain a supercooled (<0°C) layer at the water surface (Newbury 1968, Michel 1971, Benson 1973, Osterkamp 1978), see Section 4.2.

Frazil Slush - Frazil ice crystals have strong cohesive properties and tend to flocculate into loosely packed clusters that resemble slush, (Newbury 1968). The clusters may continue agglomerating and will eventually gain sufficient buoyancy to counteract the turbulence and float on the water surface. This slush is highly porous. Samples collected at Gold Creek in October 1981 yielded a ratio of water volume to ice volume of 70-80 percent.

Ice Constrictions - Slush ice drifts downstream at nearly the same velocity as the current. The velocity of the slush can be affected by surface constrictions caused by border ice shelves. These constrictions generally occur in areas of similar channel configuration where the thalweg is confined to a narrow deep channel along a steep bank. The current exerts a steady frictional force on the underside of the the slush cover. When entering constricted areas, the slush is therefore forced to compact and the density of the ice increases. The slush ice continues to pass through the channel surface constriction and is extruded from the downstream end as a long continuous, unbroken ribbon of ice. The structural competence of the ice layer is greatly increased since the water filled interstices between the ice crystals have collapsed. As the layer of compressed slush accelerates away from the constriction, it begins to fragment into floes of various sizes, depending primarily on the flow distribution in the channel. Generally, the rafts break into floes averaging 2-3 feet in diameter unless an extremely turbulent reach is encountered where the floes disintegrate and emerge once again as small slush clusters.

Ice Bridges - When the air temperatures become very cold (e.g. -20°C), and/or the density of the compressed slush is high, then the viscosity of the floating ice will increase until it can no longer be extruded through a channel surface constriction. In this event the continuous slush cover over the water surface freezes resulting in an ice bridge. Ice floes contacting the upstream (leading) edge of the ice bridge will either accumulate there or be subducted underneath the ice cover. The stability of ice against the leading edge is critically dependent on the water depth and velocity. Surface water velocities exceeding 3 ft/sec generally prevent ice accumulation, (Newbury, 1968).

Snow Slush - Slush ice has been observed to form during heavy snowfalls, (Newbury 1968, Michel 1971, R&M 1982d). The influx of snow crystals dramatically increases the ice discharge. Upon contact with the water surface, the snow crystals undergo an immediate metamorphosis into slush which is indistinguishable from frazil slush. Observations at Gold Creek and Talkeetna indicate that the influence of snowfall on slush ice discharge is significant and could affect the rate of ice cover progression on the Susitna River below Talkeetna during years of low frazil generation. Figures 4.1 and 4.2 show the relationship between daily air temperature, snowfall and ice concentration at Talkeetna and Gold Creek respectively.

The first occurrence of visible slush ice during the past season was on October 12, 1982, coincident with the first heavy snowfall of the year. It is interesting to note that the observed ice concentration does not correlate with air temperature, according to the relationships in the figures described above. The air temperatures at Talkeetna were not low enough (-2.5°C) to substantially increase the frazil ice concentration and although the air temperature at Denali was low enough (-10°C) to generate ice, it could not have influenced the ice concentration at Talkeetna on the same day. Travel time between Denali and Talkeetna, a distance of more than 160 river miles, is approximately 1.5 days at a flow velocity averaging 6 ft/sec. The calculated ice discharge for the 10% estimated surface coverage at Talkeetna on October 12, 1982 is 30 cfs or approximately $2.5x10^6$ cubic feet of ice per day. Assuming that little or no frazil was contributing to the slush ice because of high air temperatures, then it can be concluded that snow has a very significant influence on slush ice concentration and therefore also on the ice cover.

Shore Ice or Border Ice - Initially, slush ice drifts into and covers the zero velocity flow margin against the river bank. Additional slush flowing downstream sometime contacts this frozen ice and accumulates against it in a layer. This layer, affected by the flow velocity, will continue to move downstream, maintaining contact with the shore fast layer. If frictional forces of the water are overcome by the shear resistance between the ice layers, then movement stops and the slush layers freeze together. Shore ice will continue adding layers by this process until the ice extends far out into the river channel where flow velocities are in equilibrium with the shear resistance of slush ice. These ice layers often constrict the surface of the flowing water and present a barrier to floating slush ice. The constrictions have been observed to become so narrow that the slush ice must be extruded through under pressure. Flows along the shoreline of the Susitna are rarely placid enough for black ice formation, however thick layers (1-2 feet) of clear ice have been found to grow under the surface slush ice.

Black Ice - Black ice forms initially as individual crystals on the water surface in lakes, zero velocity areas in rivers and underneath an existing ice cover (Michel, 1971). These crystals all develop uniformly in the same direction, with the c-axis of the crystal perpendicular to the thermal gradient. This orderly arrangement results in a compact structure with relatively few crystal boundaries and therefore less potential for a structural failure in the ice sheet. Black ice developing in the absence of frazil crystals is characteristically translucent. This type of ice often grows into clear layers several feet thick under the Susitna slush ice cover. In contrast, water saturated slush ice (such as most border ice) is opaque, that is, usually white or blue in appearance. Ice cover rigidity and structural competency is generally dependent on the initial ratio of water volume to slush ice volume (Newbury, 1968). Black ice, which contains no slush is therefore extremely strong (shear resistant) even in relatively thin layers. The large, well rounded crystals of drained slush ice, however, produce floes which are inherently weak and will easily fragment.

Hummocked Ice - This is the most common form of ice cover on the Susitna. Essentially it is a continuous accumulation of slush, ice floes, and snow that progresses upstream during freeze-up. This process will be described in Section 4.3.

4.2 Frazil Ice

Development of an ice cover on the Susitna River is a complex process influenced by many variables and mechanisms that are not fully understood. The ice on this river is primarily a continuous accumulation of frazil slush and snow slush. It is therefore important to understand the relationship and significance of air temperature, water temperature, turbulence and suspended sediment to frazil ice generation. Little data on these variables has been collected.

Frazil ice crystals are formed when water becomes supercooled. Supercooling is a phenomena by which water remains in a liquid state at temperatures below 0°C. Controlled, uniform laboratory conditions can supercool pure water to as low as -30°C. Under natural conditions, river water will supercool only a fraction of a degree below 0°C (Osterkamp 1978, Benson 1973) before frazil ice forms. Studies dealing with frazil formation have not established a mechanism to explain this order of magnitude difference in crystallization temperature. Theories on ice nucleation processes have been developed based partly on experiments conducted in cloud physics. Foreign particles are associated with the nucleation of ice crystals and rivers normally contain an abundance of suspended sediment and organic material. The Susitna River discharges tremendous volumes of silt and clay size particles prior to freeze-up which may initiate nucleation of ice. No specific studies have been conducted to date on the Susitna River to substantiate the relationship between frazil ice formation and suspended sediment. However, there is an apparent correlation between the first occurrence of frazil ice and a sudden, at times overnight, visual reduction of turbidity in the river water.

During the month of September and generally, the first 3 weeks in October, Susitna water temperatures drop from 8.5°C to 0.5°C at Devil Canyon with similar temperature reductions at various other locations, (Table 4.1). With sustained air temperatures below 0°C, a thin layer of water will be cooled to the freezing point and ice crystals will form. Under quiescent conditions, the crystals will form on the water surface, eventually bonding together into a sheet of black ice, and continuing to grow vertically along the thermal gradient. Laboratory experiments have determined that flow velocities of only 0.79 ft./sec. are necessary to mix the surface layer sufficiently to produce frazil (Osterkamp, 1978). These velocities are exceeded on the Susitna mainstem through most reaches so the water body is continually being turned over. Under these conditions, the water can be supercooled to several hundredths of a degree below 0°C and frazil ice crystallizes.

No substantial volume of ice has been observed on the Susitna until air temperatures fall below -10°C. Observation of first frazil occurrence, however, have only been made visually and on the Susitna, low volumes of frazil cannot be seen by casual inspection from a helicopter. For example, at lower ice discharges with air temperatures at -3°C, frazil crystals may not be forming in sufficient quantities to agglomerate into ice clusters large enough to appear on the water surface. Individual crystals tend to remain suspended in the flow, lacking the buoyancy required to counteract the turbulence. With colder air temperatures, (e.g. -10°C) more ice may be generated, increasing the concentration of ice crystals. Frazil ice has strong cohesive properties and tends to flocculate into clusters of several individual crystals. The frazil floes may in turn agglomerate with other floes to form masses of slush varying in size depending on flow conditions.

Channel morphology seems to play an important role in controlling frazil agglomeration as indicated by ice plumes. These plumes are an early indicator of frazil ice and have been observed at several locations between Talkeetna and Vee Canyon where otherwise no ice was seen. The sites seem to have a similar channel configuration. Most occur at sharp river bends caused by outcrops protruding into the channel. The rock outcrops often create an eddy or slight backwater effect on the upstream side. Frazil floes, in suspension, are swept into these areas and swirl about, greatly increasing the potential of collision and adhesion with other floes. If the resulting slush balls gain sufficient mass and buoyancy, they encounter a higher velocity and more linear flow near the surface and are carried downstream. The slush exits floating in a long narrow stream which is rapidly dissipated by velocity and flow distributions. Any subsequent turbulence can re-entrain the slush into the flow rendering it once again difficult to observe. In September these ice plumes are often observed near Gold Creek, river mile (RM) 136, and Slough 9, RM 128.5 At these sites the air temperature is usually above freezing and once the ice surfaces it may melt.

During September and October of 1982, the river water in the upper Susitna Basin (between Watana and Denali) was exposed to significantly colder temperatures as well as a longer cold period than the lower river below Talkeetna (Section 3). These meteorological trends and the shallow, turbulent, and swift flowing water common in the upper basin probably cause supercooling and the generation of frazil ice weeks before these processes occur in the Devil Canyon to Talkeetna reach. The volume of ice generated in the upper basin could have critical significance to the rate of ice cover development on the lower river below Talkeetna.

It has been assumed in earlier reports that the majority of frazil ice was generated in the rapids of Devil Canyon, Watana Canyon and Vee Canyon. Although this holds true after November, the difference in the number of freezing degree days between Denali (370) and Talkeetna (170) in October suggests that the majority of the frazil slush accumulating against the leading edge downstream of Talkeetna originates in the upper river near Denali. On October 21, 1982 an attempt was made to verify this by estimating the ice discharge at various locations during a low level overflight from Talkeetna to Watana.

The estimate was based on a method described by Michel (1971) in which the total ice discharge can be calculated using:

$$I = \sum_{i=o}^{m} n_i \; v_i \; h \Delta B$$

where n_i is the percentage of slush ice covering the channel surface, v_i is the velocity, h is the total effective ice thickness and B is the ice flow width. The percentage of ice and the flow velocity were estimated visually. The channel width was known from cross section surveys and used to estimate flow width.

Samples of slush ice were collected at Gold Creek during a heavy slush ice flow in mid-October, 1981. The percentage of water volume to ice volume in a 1 liter sample of slush averaged 60%. This value was then used for "e" in the following equation for calculating the total effective ice thickness (h):

$$h = h_o + (1 - e)\, h_f$$

where h_o is the thickness of the solid part of the floe and h_f is the thickness of slush under the floe. A solid layer in the slush was never observed so $h_o = 0$. The thickness of the slush was extremely variable so for this estimate an average of .5 ft was used. Velocities at the cross sections were consistently 4 ft/s with an ice flow width of 200 ft.

Thus, if ice was being generated in the reach between Talkeetna and Watana, then the net ice discharge would be expected to decrease upstream. The final calculated ice discharges, however, consistently remained between 100-120 cfs all the way upstream to the confluence of Watana Creek. It was evident from this survey that rapids at Devil Canyon and Watana were not contributing significantly to the estimated total ice discharge of 3.6×10^5 cu ft/hr on that day in mid-October. The majority of the ice was being generated further upstream beyond Watana Creek.

Frazil ice crystals have a propensity for adhering to any object in contact with the river flow. When frazil adheres to rocks on the channel bottom it is commonly referred to as anchor ice. Anchor ice has been observed to develop into ice dams on the reach between Indian River and Portage Creek as a result of extreme accretion. Although these ice dams do not attain sufficient thicknesses to create extensive backwater areas, they increase the water velocity by restricting the cross sectional area. The configuration of the accretions is such that they may affect the stability of the flow, creating turbulence which could increase frazil generation.

Anchor ice on the Susitna River is a relatively short term icing feature. On days with intense solar radiation or warm air temperatures, this ice has been observed to release from the channel bottom and float to the water surface, often carrying with it an accumulation of sediment. These surfaced anchor ice floes will drift downstream to eventually become part of an ice cover. Because of the high sediment concentrations (silt, sand and some small gravel), these ice floes remain easily identifiable even after they are incorporated into the advancing ice cover.

4.3 Ice Cover Development

This section discusses ice cover formation on the Susitna River from the mouth at Cook Inlet to the proposed damsite at Watana. For the purposes of this discussion, the river has been separated into 4 reaches: Cook Inlet to Talkeetna, Talkeetna to Gold Creek, Gold Creek to Devil Canyon, and Devil Canyon to Watana. An additional section describing the unique freeze-up process in Devil Canyon is included.

4.3.1 Cook Inlet to Talkeetna

The initiation of ice cover formation occurred suddenly when tremendous volumes of slush ice failed to pass through a channel constriction near RM 10, adjacent to Alexander. The exact date of this event is uncertain. On October 21, 1982 a field crew was operating at the mouth of the Susitna and reported flowing slush but not in substantial volumes. On October 26, 1982 aerial reconnaissance revealed the ice bridge at RM 10 as well as an unconsolidated ice cover up to RM 67 near the confluence of Sheep Creek. Thus, sometime between October 21 and October 26 the slush ice jammed at RM 10 and accumulated upstream 57 miles. Daily ice discharge estimates from Talkeetna (Table 4.2) showed a sudden increase in ice concentrations beginning on October 21 with 1.3×10^5 cu ft/hr and rising steadily to 5.8×10^5 cu ft/hr on October 26. Assuming that the ice cover began progressing upstream on October 22, then the progression rate of 11.5 miles per day is extremely fast, (see Figure 4.3). The ice cover was unconsolidated and few sections showed any compaction or telescoping. Open water was visible between the slush ice rafts. The cover appeared relatively thin (about 1 foot) although no measurements were made. Judging from the margin of flooded snow on the channel banks, the staging amounted to only .5 - 1 foot between RM 10 and RM 25 (Susitna Station). The flow discharge at Sunshine, based on provisional USGS estimates, ranged from 16,000 cfs on October 21 to 14,000 cfs on October 26.

Upstream from RM 25 on October 26, the ice cover was no longer continuous. There was no ice cover, or evidence of ice progression on the Susitna near the confluence of the Yentna River. The Yentna was also completely free of drifting ice and shore ice. At RM 32, a loosely packed ice cover resumed and continued upstream to RM 67. Staging rarely exceeded 2 feet and large open water areas appeared frequently in the ice pack. Surprisingly little consolidation of the ice pack had taken place. An explanation for this could be the shallow gradient of the channel through this reach. If velocities remain low then the ice will continue advancing simply by juxtaposition, advancing at a rate proportional to the ice discharge and channel configuration. Based on the rate of ice advance through this reach and the unconsolidated nature of the ice cover, it is probable that the Froude number at the leading edge remained well below the critical value of 0.08 so that no thickening of the ice cover was necessary for upstream ice progression. Slush ice observed at the leading edge was not submerging under the existing ice cover. From RM 67 to RM 97 near Talkeetna, the river remained free of shore ice even though a large volume of slush ice was continually drifting downstream. All of the major tributaries to the Susitna below Talkeetna were still flowing and remained ice-free. The discharge from these tributaries kept large areas at their confluences free of ice.

On October 28, the existing ice cover received a layer of snow 183 mm deep. Observations on the 29th revealed no further compaction of the ice pack. Open water areas between the slush floes had frozen and were covered by snow. The ice pack remained confined to the thalweg channel with the exception of some side channel confluences where staging had created local backwater pools into which slush ice had drifted. The leading edge of the ice pack on October 29 was near RM 97, just upstream from the Parks Highway Bridge and adjacent to Sunshine Slough. The ice cover remained discontinuous however, with long open water areas at the Yentna River confluence near Susitna Station, the Deshka River confluence, Kashwitna Creek, and Montana Creek. These tributaries were still flowing but showed signs of an ice cover beginning to develop. At RM 76, the cover appeared extremely loose packed with individual slush rafts discernible within the cover. No movement was detected and the unconsolidated arrangement may have been stable.

From RM 76 upstream to RM 87 the ice cover was thin and discontinuous with long open water leads adjacent to Rabideux Slough and in a side channel that extended from ½ mile below the confluence of Rabideux Creek downstream for about 1 mile. The ice pack was diverting water into this side channel which had begun to develop an ice cover by slush ice accumulation. The confluence with Montana Creek was flooded by an approximate 1 foot stage increase on the mainstem. Rabideux Slough was breached through two entrance channels. This was indicated by flooded snow only and no slush ice was flowing into the slough. The margin of flooded snow was particularly evident near the Parks Highway

Bridge, where it extended all the way to the northwest abutment. The ice pack remained confined to the thalweg channel along the southeast end of the bridge. No gravel islands were observed to have been overtopped by the ice pack. No telescoping of the ice cover was evident and the ice pack remained in the narrow thalweg channel which in most areas constitutes only 20 percent of the flat, broad river channel.

The leading edge had advanced to RM 95 by November 2 at a rate of 2.1 miles per day during the previous 4 days. The stage had increased substantially in the vicinity of the leading edge causing water to flow out of the thalweg channel and flood the surrounding snow cover for several hundred feet. Many side channels had filled with water and the surface of the ice pack was near the vegetation line along the left (east) bank. The staging effects, however, were confined to the eastern half of the river, where the channel is split by a forested island. The channel along the west bank remained dry and snow covered.

By November 4, river ice observers reported rapid and extreme stage increases as the leading edge approached Talkeetna (Table 4.2). An ice jam at the Susitna and Chulitna confluence had greatly reduced the volume of slush ice flowing past Talkeetna, slowing the rate of ice cover advance substantially. On November 2 a staff gage at Talkeetna had been dry, with the nearest open water more than 1 foot below the gage. The staff gage was not again accessible until after consolidation and freezing of the ice pack on November 17 at which time the ice surrounding the gage corresponded to a reading of 3.6 feet. This represents a stage increase of over 4 feet at Talkeetna due to the ice cover advance.

After the initial ice cover formation, the remainder of the freeze-up process required considerably more time. Many of the side channels that were flooded by the increased stage in the mainstem gradually became narrower as shore ice layers built up along the channel banks and the flow discharge decreased. By early March, when discharge in the mainstem had dropped to less than 4,000 cfs at Sunshine, most open water had disappeared The continuous gradual reduction of flow also caused the ice cover to settle. Where the sagging ice became stranded, it conformed to the configuration of the channel bottom and created an undulating ice surface. Open water areas persisted throughout March in high velocity zones but were rare and generally restricted to sharp channel bends and shallow reaches in side channels which had originally been bypassed by the ice front. Some side channels and sloughs may receive a thermal influx form groundwater upwelling which would have been sufficient to keep these channels ice free. An open lead located at the end of the Talkeetna airstrip remained all winter although it gradually decreased in size.

The following sequence summarizes the highlights and general freeze-up characteristics of the lower river from Cook Inlet to Talkeetna during 1982-1983.

1. Ice jam occurs at a channel constriction near the mouth of the Susitna during a high slush ice discharge.

2. Rapid upstream advance of an ice cover by slush accumulation.

3. Thin, unconsolidated initial ice cover.

4. Minimal staging, 1-2 feet up to Sunshine, then 2-4 feet near Talkeetna.

5. No telescoping or spreading out of the ice cover due to consolidation. Ice cover generally is confined to the thalweg channel.

6. Tributaries continued flowing through December.

7. The following sloughs were breached with only minimal flow and little ice:

   a. Alexander Slough, upper end only, no through flow.

   b. Goose Creek Slough, no through flow.

   c. Rabideux Slough, minimal flow.

   d. Sunshine Slough, upper end only, no through flow.

   e. Birch Creek Slough, minimal flow.

8. Flooded snow along channel margins, variable widths.

9. High initial width discharges (16,000 cfs at Sunshine) and low final discharges (5,000 cfs).

10. No overtopping of gravel islands.

11. Some surface flow diverted into connecting side channels.

12. Ice cover sagging due to decreases in discharge.

13. Persistence of open leads in side channels and high velocity zones through March.

14. Surface area decrease of open water by steady ice accumulations and decline of water table elevations.

15. Thick, thermal gradient or clear ice buildup under slush ice cover.

16. Minimal shore ice development due to lack of sufficiently cold air temperatures before ice cover advances.

4.3.2 Talkeetna to Gold Creek

Slush ice was first observed in the Susitna River at Talkeetna on October 12, marking the beginning of freeze-up. Ice studies during previous years have observed slush ice as early as September. In 1982, however, no field crews reported ice until after the snow storm on October 12. Ice continued flowing, in varying concentrations, through the reach between Gold Creek and Talkeetna until November 2, 1982 when an ice jam occurred at the Susitna and Chulitna confluence. This jam was the starting point for the ice cover that developed over this reach.

Events during the 22 days prior to the ice jamming at the confluence are of significance and will be described first. This reach of river was subjected to colder air temperatures and more flowing slush ice than the river below Talkeetna. Shore ice, therefore, had an opportunity to develop and at several locations actually extended far out into the channel, effectively constricting the slush ice flow. The higher velocities kept the slush ice moving through the constrictions and no ice bridges formed primarily because of the steeper gradient of this reach. At the Susitna and Chulitna confluence, the flow from the Susitna enters an area of lesser gradient and the velocity is reduced substantially.

The Susitna River contributes approximately 80 percent of the ice while the Chulitna and Talkeetna Rivers combined produce the remaining 20 percent. The high (4-5 ft/sec)velocities of the Susitna keep the river channel open and push the slush ice downstream. After entering the confluence area, the masses of slush ice lose velocity and begin to pile up at the south bend of the Susitna adjacent to the entering east channel of the Chulitna. This process was observed on October 18, 1982. The slush was still moving easily through this area but was covering all of the open water for about 600 feet with a translucent sheet of compressed slush ice. The status of this ice accumulation was monitored frequently during October. On October 29, the ice was being compressed and barely kept moving by the mass of the upstream ice and by the water velocity underneath the cover. The ice through this area was no longer translucent but white since the slush had consolidated and increased in thickness sufficiently to rise higher out of the water and partially drain.

The ice constrictions being monitored on this reach were located near Curry (RM 120.6), Slough 9 (RM 128.5) and Gold Creek (RM 135.9). Slush ice was passing easily through these narrows on October 26 but was being compressed into long narrow rafts which usually broke up within several hundred feet. Unlike the confluence area, these constrictions were formed by successive layers of frozen slush ice along the shore.

A snow storm immediately preceded the formation of the ice bridge at the Susitna and Chulitna confluence. This storm may have caused a substantial local increase in ice discharge which could not pass through the channel at one time. The result was a sudden consolidation of the ice cover that compacted the slush and at some point became shore-fast. The cover remained stable long enough to freeze and increase in thickness. The majority of the incoming slush ice floes accumulated against the leading edge and the cover began advancing upstream. Approximately 10-20 percent of the slush ice submerged on contact with the upstream edge and either adhered to the underside of the cover or continued downstream. Ice discharge estimates were substantially lower after November 2 (Figure 4.1). The most dramatic effect of the ice consolidation at the confluence was flooding. The flow capacity of the ice choked main channel was greatly reduced and water spilled out from underneath the cover and flowed laterally across the river channel towards the opposite (north) bank. In addition, much water was diverted upstream by the ice jam and also flowed into the new channel. These diverted flows combined and entered the Chulitna east channel approximately 1,500 feet upstream of the original confluence. The total estimated discharge of the diverted flow was 700-1000 cfs. The discharge at Gold Creek, on November 2, based on provisional USGS estimates, was 4,700 cfs. Therefore, 15-20 percent of the total flow was bypassing the ice jam. There may have been substantial channel erosion caused by these diverted flows. Subsequent depth measurement through the ice located a isolated channel about 700 feet from the left bank that previous cross section surveys had not found. Only precise cross sectioning, however, could conclusively determine to what extent flow diversions were scouring localized channels.

After the jam stabilized, the ice pack advanced slowly due to the increased gradient. The slush ice could no longer accumulate by simple juxtapostion as the high flow velocities submerged the slush on contact with the leading edge. The entire ice cover had to thicken in order to increase the stage and lower the velocity before ice could continue accumulating against the upstream edge.

On November 9, 1982 the leading edge was beyond RM 106 near Whiskers Creek and the ice advance appeared to have stalled. The upstream edge was located adjacent to the head of a flooded side channel. The ice cover was staging in order to overcome supercritical velocities at the leading edge, however, with every ice pack consolidation and subsequent increase in stage, more water poured into the side channel and effectively prevented any extensive backwater development upstream of the ice cover. This side channel needed to fill with ice before the mainstem ice pack could continue the advance. The water being diverted into the side channel contained a high ratio of slush ice to water volume since only the surface layer of the mainstem flow was affected and therefore, the channel quickly became ice-filled.

The rate of ice advance was 1.6 miles per day for thirteen days after passing Whiskers Creek. On November 22 the leading edge was situated adjacent to Slough 8A with the total discharge, estimated from Gold Creek, at 3,300 cfs, a decrease of 900 cfs since November 9. The ice cover had staged approximately 3.4 feet and was overtopping the berm at the head of Slough 8A. At the mouth of Slough 8A, near Skull Creek, the estimated discharge was 138 cfs. Much slush ice was carried in the flow and accumulated in low velocity pools. Within 5 days this slough had developed an ice cover of consolidated slush from the mouth to the head near RM 126.5. However, the cover was extremely unstable and as the water level dropped in the slough, the ice collapsed over the channel and eventually disappeared, leaving 1-2 foot layers of stranded ice on gravel bars and open water in long narrow leads.

The ice cover was very slow in advancing through the shallow section of river between Sloughs 8A and 9. On December 2, a sudden rise in the water table at Slough 9, recorded electronically in a ground water well, indicated the proximity of the leading edge (Figure 4.4). The well was located adjacent to RM 129.5 giving an advance rate of only 0.3 miles per day for the previous 10 days even though high frazil slush discharges were estimated at Gold Creek (Figure 4.2). This may reflect the consequences of the staging into Slough 8A which were similar to those observed in the side channel near Whiskers Creek and described earlier.

On December 9 the leading edge had reached RM 136, just downstream of the Gold Creek Bridge. The ice cover advance was stalled here and remained for over 30 days as the ice needed to accumulate in thickness before it could stage past this high velocity channel constriction. Ice discharges estimated at Gold Creek steadily decreased through December primarily because the upper river was freezing over, eliminating the air/water interface needed for frazil production. Finally, on January 14, 1983 the leading edge crept past the Gold Creek Bridge at a rate of 0.05 miles per day. The discharge on January 14 at Gold Creek, based on provisional USGS estimates, was 2,200 cfs, see Tables 4.3 to 4.6.

The processes of ice cover telescoping, sagging, open lead development and secondary ice cover progression are important characteristics through this reach and deserve comment. Telescoping occurs during consolidation of the ice cover. When the velocity at the leading edge is subcritical, ice floes drifting downstream will contact the edge, remain on the surface, and accumulate upstream by juxtaposition at a rate proportional to the concentration of slush ice in the flow and channel width. This buildup will continue until a critical velocity is encountered and the leading edge becomes unstable with ice floes submerging under the ice cover. This accumulation zone can be extremely long and is generally governed by the local channel gradient, amount of staging and extent of the resulting backwater (Figure 4.3 and Table 4.8).

The pressure on a thin ice cover increases as ice mass builds up and higher velocities are reached in conjunction with upstream advance. At an undetermined critical pressure, the ice cover becomes unstable and fails. This sets off a chain reaction and within seconds the entire ice sheet is moving en masse downstream. This represents the consolidation phase of ice cover stabilization. Several miles of ice cover below the leading edge can be affected by consolidation. The results of this process are a shortening of the ice cover, substantial thickening as the ice is compressed, a stage increase, and telescoping. The stage increase is caused by the ice thickening which creates a local restriction to flow. The telescoping occurs only during each consolidation. As the ice compresses downstream, tremendous pressures are exerted on the ice cover below the accumulation zone. Here the ice mass will shift to relieve the stresses exerted on it by the upstream cover, often becoming thicker in the process. This will tend to further constrict the flow resulting in an increase in stage. As the stage increases, the entire ice cover lifts and any additional pressures within the ice cover can then be relieved by lateral expansion of the ice across the river channel. Generally this process can continue until the ice cover has expanded bank to bank or encounters some other obstruction such as gravel islands on which the ice becomes stranded.

The ice cover over water filled channels will continue to float. Because of constant contact with the flowing water, the ice cover erodes rapidly, sagging at first and eventually collapsing. In some reaches these open leads can extend for several hundred yards. The lengths and widths of these leads, as well as rates of collapse and secondary ice cover development can be determined from aerial photographs (Table 4.9).

A secondary ice cover generally accumulates in the open leads and usually completely closes the open water by the end of March. The process is similar to the initial progression except on a smaller scale. Slush ice begins accumulating against the downstream end of the leads and progresses upstream. Generally it takes several weeks to effect a complete closure.

Ice cover sagging, collapse, and open lead development usually occur within days after a slush ice cover stabilizes. A steady decrease in flow discharge gradually lowers the water surface elevation along the entire river. Also, the staging process which had raised the water surface within the thalweg channel tends to seek an equilibrium level with the lower water table by percolating through the gravels of the surrounding terraces. Percolation of river water out of the thalweg channel and the subsequent charging of the surrounding water table is currently under study. This process is being documented by recording the relationship between mainstem water surface elevations and relative stage fluctuatons in groundwater wells located on terraces near Slough 9, (Figure 4.4). Examination of aerial photographs of the sloughs taken during the ice cover advance up the mainstem revealed an increase in the wetted surface area. This increase was due to a rise in the water table since the sloughs are generally isolated from the mainstem at discharges of less than 25,000 cfs and the average discharge at Gold Creek in December is under 4,000 cfs.

Many sloughs receive flow from groundwater seeps throughout the winter. This continuous thermal influx (4°C) prevents a stable ice cover from forming. The seeping water originates from the unconsolidated gravels underlying the surrounding terraces and river bed. This intragravel watertable tends to permeate through the interstices at a rate dependent on the porosity and gradient of the gravel bed. If a scarp or channel should intersect this riverine watertable at an elevation below the local water surface then seeps will appears along the bank, or fill the intersecting channel. The water surface in the channel will then reflect the adjacent watertable elevation. Once exposed the water will follow the shallow gradient of the slough.

This relatively warm, laminar flow will develop ice along the margins which may constrict the surface area to a narrow lead. This lead however, rarely freezes over and often extends for thousands of feet downstream, (Table 14). Open water was observed all winter in the following sloughs above the Chulitna confluence:

Slough 7
Slough 8A
Slough 9
Slough 10
Slough 11
Slough 16
Slough 20
Slough 21
Slough 22

As previously described, Slough 8A was the only slough breached by slush and consequently the only one to develop a continuous ice cover. The thermal influence of groundwater however, quickly eroded through the frozen slush ice cover and an open lead remained for the duration of winter.

The 1982-1983 freeze-up characteristics on the Susitna River between Talkeetna and Gold Creek are summarized as follows:

1. Frazil ice plumes appearing as early as September but more commonly, in early October.

2. Velocities between 2-5 ft/sec.

3. Discharges at Gold Creek ranging from 4,900 cfs on November 1 to 1,500 cfs by the end of March.

4. Ice jam initiating the ice cover progression from the Susitna/Chulitna confluence.

5. Gradually decreasing rate of ice advance from 3.5 miles per day near the confluence to 0.05 miles per day at Gold Creek.

6. Flow diversions into side channels and sloughs.

7. Ice constrictions by border ice growth.

8. Staging, commonly from 2-4 feet.

9. Ice pack consolidation.

10. Telescoping of ice cover laterally across channel.

11. Sagging ice cover.

12. Open leads and secondary ice covers.

13. Berms breached at Slough 8A.

14. Staging effects on the local water table.

15. Thermal influx by groundwater seepage prevents ice cover formation in sloughs that are not breached and inundated with slush.

4.3.3 Gold Creek to Devil Canyon

The freeze-up processes affecting this river reach are vastly different from those responsible for ice cover development below Gold Creek. Although the air temperatures here do not vary considerably from Sherman or Talkeetna, this reach undergoes much shore ice growth, development of anchor ice dams, and overflow primarily because of the long period required for the ice pack to advance into this reach. In fact, most of this reach had frozen over by other means before the leading edge of the ice progressed past Gold Creek. Therefore, the leading edge was extremely difficult to follow and eventually became indistinguishable just below the Indian River confluence. Because short-term changes in ice cover development in this reach are difficult to detect, a description of the general processes involved rather than a chronology is provided here.

The most significant features of freeze-up between Gold Creek and Devil Canyon are wide border ice layers, ice accretions on rocks surrounded by border ice, and formation of ice covers over eddies. Gradually, the border ice layers constrict the channel to a width of 20-30 feet before they fill with slush and freeze over. Frazil and frazil slush tends to be drawn into the turbulent eddies behind large boulders in the streamflow. These eddies can have near zero velocities on the surface, so often the floating slush adhered to the rock or to other slush ice and freezes. This surface layer of ice may continue accumulating slush until the entire eddy area is frozen over.

Ice dams have been identified at several locations below Portage Creek. Generally, the dams form when the rocks on which the frazil adheres are located near the water surface. When air temperatures are cold ($<$ -10°C), the ice covered rocks will continue accreting additional layers of frazil until they break the water surface.

These dams effectively increase the water turbulence which may, in turn, stimulate frazil production and thus accelerate ice dam formation. The ice dams are often constricted by border ice. This creates a backwater area by restricting the streamflow so that it can only pass over the ice dam. This subsequently causes extensive overflow onto the border ice. The overflow will bypass the ice dam and re-enter the channel at a point further downstream. Within the backwater area, slush ice accumulates in a thin layer from bank to bank and eventually freezes.

An ice bridge generally forms early in November just upstream of the Portage Creek confluence. This ice bridge does not, however, initiate an ice cover progression because of its proximity to a shallow rapids with velocities supercritical for ice cover formation.

This reach from Gold Creek to Devil Canyon freezes over gradually and much later than the lower river. It is generally ice covered by early March, a full two months after the river downstream of Gold Creek has developed a stable ice cover. The delay can be explained by the relatively high velocities encountered despite the low discharges and the absence of a continuous ice pack progression through the reach. Also, the relatively warm discharges from Portage Creek and Indian River tend to keep the river free of ice until the flows from these tributaries become insignificant relative to the Susitna discharge.

To summarize, the following are the significant freeze-up characteristics of the river reach between Gold Creek and Devil Canyon.

1. Steep gradient, high velocities, single channel.

2. Minimal continuous ice cover progression, usually only formation of local ice covers separated by open leads.

3. Late freeze-over, generally in March.

4. Extensive border ice growth, very wide layers of shore-fast ice.

5. Constricted channel, narrowed substantially by border ice.

6. Ice dams create local backwater areas which form ice covers.

7. Ice covers over eddies which form behind large boulders in streamflow.

8. Some telescoping, usually not widespread.

9. Minimal staging.

10. Extensive overflow.

11. Few leads opening after initial ice cover.

12. No sloughs breached, no diverted flow into side channels.

13. Minimal ice sagging.

14. Thermal influx by groundwater seeps keeps sloughs open all winter.

4.3.4 Devil Canyon (to Devil Creek)

The Geophysical Institute of the University of Alaska, Fairbanks, furnished a time-lapse camera so that the ice cover formation in Devil Canyon could be documented. Ice processes occurring in this area have not been well understood since direct observation is often impossible. The camera was mounted on the south rim of the canyon, adjacent to the centerline of the proposed dam. The reach to be filmed extended downstream of this site for approximately a half mile (Figure 4.5). This area seems to accumulate the thickest ice cover not only in the canyon but also on the entire Susitna River. Surveys conducted in the canyon during the previous 2 winters have measured ice shelf thicknesses up to 23 feet (R&M 1981c). This thickening is known to have occurred in stages, each adding a new layer of ice on top of the existing cover. The duration and mechanism of this event could only be determined by direct observation of each ice flood. The sequence of events was therefore filmed by a remote, 8 mm movie camera programmed to expose 20 frames every hour on the hour. The camera was installed on October 18, 1982 and was allowed to run continuously until February 7, 1982. On the day of installation, one ice advance and subsequent ice cover collapse had already occurred, depositing approximately 2 feet of ice on the boulder strewn channel banks.

The following chronological sequence of events was compiled from examination of the film. The descriptions will begin on a daily basis when much ice activity was documented and taper to weekly and then monthly descriptions as fewer changes were observed. Air temperatures (mean daily °C) were obtained from the meteorological record of the Devil Canyon weather station. Streamflows are provisional estimates from the Gold Creek Station and are subject to revision by the U.S. Geological Survey. Ice thicknesses are estimates from the film record. Measurements were attempted during ice formation, however, the ice cover remained too unstable for helicopter landings.

October 18, 1982 - Air temperature -5.0°C, discharge 6,720 cfs. The channel appeared open with no ice bridges and no constrictions. There was 1-2 feet of shore-fast ice on the channel banks.

October 19 - Air temperature -3.2°C, discharge 6,900 cfs. It was snowing heavily and the channel was partially obscured. It appeared to be completely filled with slush ice with no open water visible. Staging of at least 3-4 feet was evident. The channel remained ice covered throughout the day and the snow ended about 2 p.m.

October 21 - Air temperature -9.5°C, discharge 6,500 cfs. No significant changes as the channel remained ice covered all day with no open leads appearing. The weather was clear and sunny with swaying trees indicating high winds.

October 22 - Air temperature -9.6°C, discharge 6,200 cfs. The ice cover began to sag in the center of the channel. The water level remained relatively high and the depression filled with water. This was probably not overflow, but instead the result of ice dropping below the water surface. The sagging center of the ice cover rapidly eroded and lengthened. The sides of the now open lead continued to calve off into the open water and the ice fragments disappeared.

October 23 - Air temperature -9.8°C, discharge 6,000 cfs. It snowed heavily early in the morning tapering off around 10 a.m. Open leads were clearly visible in the high velocity reaches. Water saturated ice remained in some areas of lower velocity where erosional forces were not as severe. Little change was noticed during the day.

October 24 - Air temperature -10.6°C, discharge 5,900 cfs. Large volumes of frazil were flowing in the open channel. An ice cover had again formed over the downstream portion of the open water lead. The upper portion remained open where apparently the water velocities were sufficiently high to prevent further ice cover progression at the prevailing ice discharge. During the day, the ice cover over the lower reach rapidly deteriorated by sagging and erosion. The floating ice cover was now sagging so far down that it sheared vertically from the shore-fast ice and floated within the open lead (Photo 21). This subjected the fragmented ice cover to the full velocity of the water which quickly eroded the ice away. The floating ice seemed to ride very low in the water, at times submerging completely. This is probably due to the high porosity of the slush ice which initially formed the cover.

October 25 - Air temperature -12.8°C, discharge 5,700 cfs. There were no apparent changes as part of the channel was still partially covered and the remainder was choked with floating water saturated ice. Ice shelves on the banks were approximately 3-4 feet thick.

October 26 - Air temperature -15.4 °C, discharge 5,600 cfs. The images of the canyon were obscured by heavy fog but the channel seemed to be ice covered with no open leads discernible.

October 27 - Air temperature -19.1°C, discharge 5,400 cfs. There were no apparent changes. The ice cover remained intact and no water was visible.

October 28 - Air temperature - 13.2°C, discharge 5,300 cfs. Overnight, an open lead developed in the upstream rapids section. No further changes were noted on this day.

October 29 - Air temperature -13.3°C, discharge 5,200 cfs. Fog again partially obscured the images. The open lead at the upstream end of the reach expanded in width and length. It appeared to be open for its entire wetted width and no overhanging ice shelves remained. This open water reach extended upstream out of the field of view. Another open lead about 300 feet downstream of the upper lead continued to increase its length by collapsing at both ends. By the end of the day, the two open leads had extended to within 50-75 feet of each other.

October 30 - Air temperature - 19.1°C, discharge 5,100 cfs. The first hour of daylight showed a long open lead partially obscured by fog. Apparently, the two leads of October 29 merged overnight when the ice bridge separating the leads collapsed and formed a narrow channel. The channel then widened considerably and the downstream end was located just above the south river bend. The upstream end was not visible, however, the upstream reach through the canyon is generally open because of extreme turbulence and high velocities.

October 31 - Air temperature -15.9°C, discharge 4,900 cfs. The channel constriction of October 31 closed again, separating the open water reaches by about 75 feet of ice. This indicates the location of the deep pool surveyed in 1981, where flow velocities tend to allow gradual accumulation of frazil slush against the channel banks (R&M, 1981c. About 1 p.m., this ice closure began to erode along the left bank.

November 1 - Air temperature -4.5°C, discharge 4,800 cfs. The first exposure of the day revealed one long open lead running almost the entire length of the visible canyon. The border ice shelves were the only ice remaining within this reach of the canyon. These appeared to have thicknesses exceeding 10 feet in some places, particularly at the upstream channel constriction. This is also usually the first area to bridge over.

November 2 - Air temperature -5.1°C, discharge 4,700 cfs. A high volume of ice seemed to be flowing and an ice cover was accumulating in the lower canyon reach. The channel at the most downstream end was filled with slush. Several advances of 20-30 feet were visible during the day. These were followed by consolidation phases during which the ice cover was compressed and the net stage increased.

November 3 - Air temperature -7.8°C, discharge 4,600 cfs. The ice cover advanced about 100 feet overnight. The cover appeared to be thin and did not come close to the top elevation of the shore ice. Although much ice was evidently flowing, it all seemed to be submerging underneath the existing cover and not accumulating against the leading edge. This indicates that the ice cover was thickening at some point downstream. No appreciable upstream advance occurred on this day.

November 4 - Air temperature -2.9°C, discharge 4,500 cfs. The ice cover had not advanced since the previous day but, instead, has thickened and staged substantially. In the lower reach, the difference in elevation between the top of the shore ice and the ice cover in the channel was no less than 2 feet.

November 9 - Air temperature -7.1°C, discharge 4,100 cfs. Little change was apparent in the ice regime despite a high volume of flowing ice.

November 14 - Air temperature - 6.2°C, discharge 3,800 cfs. The past 5 days showed little change in the shape or size of the open lead except for minor advances of 10-20 feet at the leading edge. These subsequently consolidated, relocating the ice front to its original position. On this day the ice cover finally closed the lower canyon reach. The upper lead remained open but a very high volume of slush ice could be seen flowing within the lead. This sudden increase in slush ice concentration was probably related to the rapid ice cover formation in the lower canyon. A correlation between snowfall on November 14 and ice discharge can be seen and is illustrated in Figure 6.

November 15-21 - Discharges from 3,700 cfs down to 3,400 cfs. Ice covers that formed repeatedly over the lower canyon reach but seemed to be extremely unstable. The covers typically lasted only a few days and destruction generally occurred coincident with a decrease in ice discharge. The duration of ice cover deterioration was variable and probably depended on velocity as well as climatic conditions.

December - January - Discharges fell from 3,000 cfs down to 2,000 cfs. No new processes were observed during this period. Snowfalls continued to stimulate heavy frazil ice loading and subsequent ice cover progression through the canyon. The ice cover over the reach finally stabilized. The final 20 days of filming showed that the ice cover over the lower reach began from the border ice constriction and extended beyond the south river bend. This cover did, however, eventually develop cracks. A sag appeared, the ice finally collapsed, and open water showed through. The final exposures, in February, clearly showed the ice cover beginning to fail along its entire length. This seems to indicate that the ice covers within this narrow and turbulent river reach are inherently unstable.

The number of ice cover advances totalled 6 on the lower reach and 3 on the upper. This difference is due primarily to a steeper gradient and thus, higher velocities and turbulence in the upper section. Only during extreme ice discharges did this reach form an ice cover. The initial ice cover developed in October over both reaches but rapidly eroded away leaving only remnant shore ice. The second major ice cover event occurred in December with the final ice cover forming in January. All of the major ice advances were related to heavy snowfalls. A storm in January left an ice cover on the lower reach which appeared to be stable. The low discharges in January probably resulted in subcritical velocities which could explain the longevity of this ice cover.

Some interesting aspects about the freeze-up of Devil Canyon were observed over the past season and deserve comment. Certainly the most unique characteristic of Devil Canyon ice is the great ice thickness. With each ice event, more ice is deposited on top of the relatively stable shore-fast ice. The shore-fast ice creates an unnaturally narrow channel which essentially decreases the water and slush ice-carrying capacity of this reach. Consequently, when staging occurs the slush must rise and therefore, even with relatively small fluctuations of flow, extreme staging may occur. The width of the winter channel is controlled by the steep canyon walls. Shore ice is initially formed by an ice cover anchoring to boulders along the channel banks. This shore-fast ice was not affected by winter flows since the ice was deposited well above the normal water surface. Only during rapid staging events was the flow constricted. Apparently, the rapid rise and decline of the water surface does not erode the shore ice significantly.

Certain sections within Devil Canyon are the first areas on the Susitna to form an ice bridge and develop an extensive ice cover. Ice covers of one mile in length have been observed to form about two miles below the Devil Creek confluence as early as October 12, despite relatively warm air temperatures.

To summarize the highlights of freeze-up in Devil Canyon:

1. Narrow, confined channel with high flow velocities and turbulence.

2. Early formation of ice bridges and loosely packed slush ice covers.

3. Formation and erosion of ice covers several times during the winter.

4. Inherently unstable ice covers, eventual collapse long before breakup.

5. Extreme staging and ice thicknesses up to 23 ft.

4.3.5 Devil Canyon to Watana

This section of the river has not been thoroughly studied. However, some general comments on the freeze-up processes affecting this reach can be made. These are based mostly on ice formations observed during breakup after the snow had melted off of the ice cover.

An accumulation of border ice layers is primarily responsible for the ice cover development. The border ice often constricts the open water channel to less than 30 feet. The slush ice then jams in between the shore-fast ice and freezes, forming an unbroken, uniform ice cover across the river channel. However, since this process does not occur simultaneously over the entire reach, a very discontinuous ice cover results. Open leads generally abound until early March when the combination of snowfall and overflow closes most of the openings.

Characteristics of freeze-up between Devil Canyon and Watana are summarized as follows:

1. Extremely wide accumulations of border ice layers.

2. Gradual filling of the narrow open channel with slush which freezes and forms a continuous ice cover.

3. Extensive overflow and flooded snow.

4. Minimal staging or telescoping.

5. Low discharges.

6. Shallow water and moderate velocities.

7. Minimal ice sagging, few leads opening after initial freeze-up.

8. Extensive anchor ice with high sediment concentrations.

4.3.6 Ice Cover at the Peak of Development

The ice cover on the Susitna River is extremely dynamic. From the moment that the initial cover forms, it is either thickening or eroding. Slush ice will adhere to the underside of an ice cover in areas of low velocity and cold temperatures will subsequently bond this new layer to the surface ice. Table 4.7 lists Susitna ice cover thicknesses from Watana to the Chulitna confluence. These measurements represent the cover at maximum development in 1983.

If the ice cover could ever be considered stable it would be at the height of its maturity in March. During this period of the winter, snowfalls become less frequent and very little frazil slush is generated. The only water contact with air occurs at the numerous open leads which persist over turbulent reaches or groundwater seeps. These are usually of short length and therefore minimal heat exchange takes place. Table 4.9 presents the locations and dimensions of most annually recurring leads between Sunshine and Devil Canyon.

Discharges in March are generally at the yearly record low, reducing the flowing. Water to a shallow and narrow thalweg channel as indicated by a depression in the ice cover. The depressions form shortly after ice cover formation when the compacted slush ice is flexible and porous. Water levels decrease through March and the floating ice cover is often grounded on the river bottom. Water gradually percolates out of the cover, and alternating layers of bonded and unconsolidated ice crystals form within the ice pack when the receding level of saturated slush freezes at extreme air temperature. The result is the formation of rigid layers at random levels, the layers representing the frequency of critically cold periods. By the end of March, the Susitna River ice has essentially metamorphosed into a stiff and impermeable cover.

TABLE 4.1

SUSITNA RIVER SURFACE WATER TEMPERATURE PROFILE* SEPTEMBER 1982 - OCTOBER 1982

	Water Temperature °C				
September 1-30, 1982	Min.	Max.	Mean	Mean 9/1/82	Mean 9/31/82
Above Yentna River, RM 29.5	4.0	9.5	7.0	8.5	4.7
Park Highway Bridge, RM 83.9	4.1	9.0	6.3	8.0	4.6
Talkeetna Fish Camp, RM 103.0	4.4	9.9	7.0	8.7	4.9
Curry, RM 120.7	4.5	9.1	6.8	8.4	4.5
LRX-29, RM 126.1	3.8	10.0	6.8	8.6	4.0
Devil Canyon, RM 150.1	4.0	9.5	6.8	8.5	4.0

	Water Temperature °C				
October 1-17, 1982	Min.	Max.	Mean	Mean 10/1/82	Mean 10/31/82
Above Yentna River, RM 29.5	0.0	5.0	1.9	4.8	0.0
Parks Highway Bridge, RM 83.9	0.2	4.6	1.2	4.6	0.2
Talkeetna Fish Camp, RM 103.0	0.2	4.9	1.2	4.7	0.2
Curry, RM 120.7	-	-	-	-	-
LRX-29, RM 126.1	-	-	-	-	-
Devil Canyon, RM 150.1	0.0	4.0	1.8	3.5	0.5

* These data were obtained from published reports by Alaska Department of Fish & Game, Susitna. Temperatures were recorded on a thermograph at all sites except Devil Canyon which was recorded electronically, (ADF&G, 1982).

s5/cc4

TABLE 4.2

SUSITNA RIVER AT TALKEETNA
FREEZEUP OBSERVATIONS ON THE MAINSTEM

Date	Staff Gauge[1] (ft)	Discharge @ Sunshine[2] (cfs)	% Ice in Channel	Ice Thickness (ft)
October 1982				
12	1.65	20,000	0	-
13	1.68	20,000	10	-
14	1.55	20,000	0	.01
15	1.42	19,000	30	.03
16	1.25	18,000	30	.09
17	1.30	17,000	25	.09
18	1.24	[illegible],000	25	.09
19	1.23	17,000	25	.10
20	1.20	17,000	20	.10
21	1.15	16,000	30	.10
22	0.98	16,000	60	.20
23	0.97	16,000	70	.20
24	0.40	15,000	75	.30
25	-	15,000	80	-
26	-1.00	14,000	90	.40
27	-1.50	14,000	90	.40
28	-1.50	14,000	90	.40
29	-1.50	13,000	85	.40
30	-1.50	13,000	80	.40
31	-1.50	13,000	80	.40
November 1982				
1	2.50	12,000	80	-
2	1.54	12,000	60	-
3	1.52	12,000	50	-
4	-	11,000	40	-
5	-	11,000	50	-
6	3.60	(Top of ice after freezeup)	50	3.30
7	3.60	11,000	70	3.30
8	3.60	11,000	80	3.30
9	3.50	10,000	100	3.30
10	3.60	10,000	100	3.30
11	3.60	9,800	100	3.30
12	3.30	9,800	100	3.30

1. Relative elevations based on an arbitrary datum.
2. Provisional data subject to revision by the U.S. Geological Survey, Water Resources Division, Anchorage, Alaska.
3. Visual estimation based on one daily observation usually at 9 a.m.

TABLE 4.3

SUSITNA RIVER AT GOLD CREEK
FREEZE-UP OBSERVATIONS ON THE MAINSTEM
October 1982

Date	Discharge (1) (cfs)	Gold Creek Mean Air Temperature (2) (°C)	Water Temperature (3) (°C)	Ice in Channel (4) (%)	Border Ice Thickness (ft)	Snow Depth (ft)	Weather
Oct. 19	6900	-1.4	0.65	50	slush	0.6	Snow
20	6800	-5.0	0.80	40	slush	0.6	Cloudy
21	6500	-5.6	1.00	60	slush	0.6	Windy/Sunny
22	6200	-4.4	0.90	60	0.3	0.6	Windy/Sunny
23	6000	-9.2	0.80	65	0.3	0.6	Windy/Sunny
24	5900	-7.8	1.00	50	0.3	0.6	Partly Cloudy
25	5700	-10.0	1.00	60	0.3	0.6	Cloudy
26	5600	-14.4	0.50	60	0.3	0.6	Cloudy
27	5400	-13.6	0.20	65	0.4	0.6	Sunny
28	5300	-7.8	0.00	65	0.4	1.0	Snow
29	5200	-6.9	0.00	70	0.5	1.5	Snow
30	2100	-18.3	0.10	70	0.7	1.5	Sunny
31	4900	-17.8	0.00	70	0.7	1.5	Sunny

1. Provisional data subject to revision by the U.S. Geological Survey, Water Resources Division, Anchorage, Alaska.
2. Average value of the days minimum and maximum temperature.
3. Based on one instantaneous measurement, usually taken at 9 a.m. daily.
4. Visual estimate based on one instantaneous observation, usually at 9 a.m. daily.

TABLE 4.4

SUSITNA RIVER AT GOLD CREEK
FREEZE-UP OBSERVATIONS ON THE MAINSTEM
November 1982

Date	Discharge (1) (cfs)	Gold Creek Mean Air Temperature (2) (°C)	Water Temperature (3) (°C)	Ice in Channel (4) (%)	Border Ice Thickness (ft)	Snow Depth (ft)	Weather
Nov. 1	4800	-2.2	0.00	70	0.9	1.5	Windy/Cloudy
2	4700	1.1	0.10	20	0.9	1.5	Snow
3	4600	-6.9	0.20	50	0.9	1.7	Cloudy
4	4500	-3.3	0.30	15	0.9	1.8	Cloudy
5	4400	-6.7	0.40	10	0.9	1.8	Cloudy
6	4300	-16.9	0.30	50	0.9	1.8	Sunny
7	4300	-17.8	0.20	55	1.0	1.8	Sunny
8	4200	-7.5	0.15	55	1.2	1.8	Snow
9	4100	-5.6	0.15	55	1.2	2.6	Cloudy
10	4000	-5.0	0.30	50	1.2	2.5	Cloudy
11	4000	-1.1	0.20	50	1.2	2.5	Snow
12	3900	-1.9	0.20	35	1.3	3.3	Cloudy
13	3800	-3.1	0.20	35	1.3	3.3	Sunny
14	3800	-1.9	0.20	30	1.5	3.4	Cloudy
15	3700	-12.2	-	40	1.5	3.4	Sunny
16	3600	-15.8	-	60	1.6	3.4	Sunny
17	3600	-15.0	-	70	1.6	3.4	Sunny
18	3500	-22.8	0.30	70	1.6	3.3	Sunny
19	3500	-25.7	0.20	75	1.7	3.3	Sunny
20	3400	-10.0	0.30	70	1.6	3.3	Snow
21	3400	-6.4	0.30	60	1.6	4.1	Snow
22	3300	-5.0	0.40	55	1.6	4.1	Sunny
23	3300	-4.4	0.30	45	1.3	4.0	Sunny
24	3200	-3.1	0.30	30	1.3	4.0	Sunny
25	3200	-2.8	0.50	40	1.2	3.9	Sunny
26	3100	-3.1	0.40	50	1.2	3.8	Sunny
27	3100	-8.3	0.40	50	1.2	3.8	Sunny
28	3100	-12.8	0.50	60	1.3	3.8	Sunny
29	3000	-9.7	0.30	60	1.3	3.8	Snow
30	3000	-8.9	0.20	40	1.3	3.8	Cloudy

1. Provisional data subject to revision by the U.S. Geological Survey, Water Resources Division, Anchorage, Alaska.

2. Average value of the days minimum and maximum temperature.

3. Based on one instantaneous measurement, usually taken at 9 a.m. daily.

4. Visual estimate based on one instantaneous observation, usually at 9 a.m. daily.

TABLE 4.5

SUSITNA RIVER AT GOLD CREEK
FREEZE-UP OBSERVATIONS ON THE MAINSTEM
December 1982

Date	Discharge (1) (cfs)	Gold Creek Mean Air Temperature (2) (°C)	Water Temperature (3) (°C)	Ice in Channel (4) (%)	Border Ice Thickness (ft)	Snow Depth (ft)	Weather
Dec. 1	3000	-7.8	0.10	30	1.3	3.4	Cloudy
2	2900	-16.9	0.10	55	1.3	3.3	Cloudy
3	2900	-16.9	0.00	70	1.3	3.3	Windy/Sunny
4	2900	-10.0	0.10	75	1.3	3.3	Cloudy
5	2800	-8.3	0.20	75	1.3	3.3	Cloudy
6	2800	-1.7	0.20	65	1.3	3.0	Sunny
7	2800	2.5	0.30	40	1.3	3.0	Windy/Cloudy
8	2700	3.6	0.20	15	1.1	3.8	Snow
9	2700	-1.9	0.20	25	1.1	3.9	Cloudy
10	2700	-16.1	0.10	60	1.2	3.9	Sunny
11	2600	-6.1	0.00	40	1.3	3.9	Sunny
12	2600	-3.1	0.00	60	1.3	3.8	Cloudy
13	2600	-1.7	0.10	40	1.3	3.8	Sunny
14	2600	-5.0	0.20	25	1.2	3.8	Sunny
15	2600	-0.3	0.20	10	1.2	3.8	Sunny
16	2500	-3.3	0.10	10	-	3.7	Sunny
17	2500	-6.7	0.10	10	-	3.7	Sunny
18	2500	-10.6	0.00	50	-	3.7	Sunny
19	2400	-11.7	0.00	40	-	3.7	Sunny
20	2400	-7.2	0.00	40	-	3.7	Sunny
21	2400	-21.1	0.00	50	0.5	3.7	Sunny
22	2400	-23.1	0.00	50	0.5	3.7	Sunny
23	2400	-15.6	0.00	30	0.5	3.7	Sunny
24	2400	-11.9	0.00	30	0.5	3.6	Sunny
25	2300	-9.2	0.10	30	0.6	3.6	Sunny
26	2300	-5.6	0.10	30	0.6	3.5	Sunny
27	2400	-1.7	0.10	35	0.6	3.5	Snow
28	2400	0.6	-	-	-	5.0	Snow
29	2600	1.7	0.10	5	overflow	3.1	Rain
30	2800	-0.3	0.10	25	overflow	3.2	Rain
31	2900	-	0.10	5	1.3	3.2	Sunny

1. Provisional data subject to revision by the U.S. Geological Survey, Water Resources Division, Anchorage, Alaska.

2. Average value of the days minimum and maximum temperature.

3. Based on one instantaneous measurement usually taken at 9 a.m. daily.

4. Visual estimate based on one instantaneous observation, usually at 9 a.m. daily.

s5/dd4

TABLE 4.6

SUSITNA RIVER AT GOLD CREEK
FREEZE-UP OBSERVATIONS ON THE MAINSTEM
January 1983

Date	Discharge (1) (cfs)	Gold Creek Mean Air Temperature (2) (°C)	Water Temperature (3) (°C)	Ice in Channel (4) (%)	Border Ice Thickness (ft)	Snow Depth (ft)	Weather
Jan. 1	2900	-2.8	0.00	8	1.3	3.2	Sunny
2	2800	-2.8	0.00	10	1.3	3.2	Sunny
3	2800	-3.9	0.00	30	1.3	3.5	Cloudy
4	2700	-5.0	0.00	60	1.4	3.5	Sunny
5	2700	-13.9	0.10	65	1.3	3.5	Sunny
6	2600	-19.1	0.10	65	1.3	3.5	Sunny
7	2500	-	0.00	70	1.3	3.5	Sunny
8	2500	-25.3	0.00	65	1.3	3.3	Sunny
9	2400	-22.2	0.00	60	1.4	3.3	Sunny
10	2400	-20.6	0.00	70	1.4	3.0	High Winds
11	2400	-16.7	0.00	85	1.4	3.0	Sunny
12	2300	-18.6	0.00	90	1.5	3.0	Sunny
13	2300	-16.7	0.00	90	1.5	3.0	Sunny
14	2200	-13.1	0.00	100	1.5	3.0	Sunny
*							

1. Provisional data subject to revision by the U.S. Geological Survey, Water Resources Division, Anchorage, Alaska.
2. Average value of the days minimum and maximum temperature.
3. Based on one instantaneous measurement, usually taken at 9 a.m. daily.
4. Visual estimate based on one instantaneous observation, usually at 9 a.m. daily.

* Channel frozen over.

TABLE 4.7

1983 SUSITNA RIVER ICE THICKNESS MEASUREMENTS

	Mainstem Ice Thicknesses (ft)			Number of Holes	Water Surface Elevation	Average* Underice Water Velocity
	Min	Max	Avg			
February 4, 1983						
Watana	1.4	3.6	2.4	21	1436.8	2.6
Portage Creek	1.4	3.4	2.5	5	834.1	
Gold Creek	1.3	1.9	1.6	5	684.6	
Curry	1.8	2.1	1.9	4	522.7	
LRX-3	2.0	3.9	2.9	5	342.8	
April 12, 1983						
Watana	1.8	4.2	2.8	19	1436.1	2.2
Portage Creek	3.0	4.0	4.1	6	833.5	4.2
Gold Creek	1.8	2.9	2.3	6	682.9	
Curry	1.3	3.3	2.2	7	521.9	
LRX-3	2.0	3.8	2.8	7	341.5	

* Average underice water velocity was measured at point of most flow and constitutes an average of the vertical velocity profile.

TABLE 4.8

RIVER STAGES AT FREEZEUP MEASURED
FROM TOP OF ICE ALONG BANKS
AT SELECTED LOCATIONS

River Mile	Location	Approximate Date of Freezeup	Elevation Top of River Bank (ft)	Maximum Ice Elevation* (ft)	Open Water Discharge Corresponding to Stage (cfs)	Actual Discharge at Gold Creek (cfs)
148.9	Portage Creek	12/23/82	843.0	839.5	27,000	2,400
142.3	Slough 21, H9	-	758.3	755.5	-	-
140.8	Slough 21, LRX-54	-	735.3	733.3	-	-
136.6	Gold Creek	1/14/83	687.0	685.3	16,000	2,200
135.3	Slough 11, Mouth	12/6/82	671.5	-	-	2,800
130.9	Slough 9, Sherman	12/1/82	622.4	620.1	30,000	3,000
128.3	Slough 9, Mouth	11/29/82	-	[6.9]	-	3,000
127.0	Slough 8, Head	11/22/82	-	579.3	-	3,300
124.5	Slough 8, LRX-28	11/20/82	556.2	559.3	44,000 (aufeis)	3,400
120.7	Curry	11/20/82	527.0	524.6	28,000	3,400
116.7	McKenzie Creek	11/18/82	-	493.3	-	3,500
113.7	Lane Creek	11/15/82	-	[6.7]	-	3,700
106.2	LRX-11	11/9/82	-	[5.3]	-	4,100
103.3	LRX-9	11/8/82	384.1	383.9	41,000	4,200
98.5	LRX-3	11/5/82	346.4	345.5	-	4,400

* Values in brackets [ ] represent relative elevations based on an assumed datum from a temporary benchmark adjacent to the site.

s16/x1

TABLE 4.9

MAJOR ANNUALLY RECURRING OPEN LEADS
BETWEEN SUNSHINE RM 83 AND DEVIL CANYON RM 151
LOCATION AND SPECIFICATIONS ON MARCH 2, 1983

Location of Upsteam End River Mile #	Channel Type	Velocity or Thermal	Approx. Length (Ft)	Widest Point (Ft)	Continuous or Discontinuous
85.0	Mainstem	Velocity	550	80	Continuous
87.1	Slough	Velocity	4,500	50	Discontinuous
87.6	Mainstem	Velocity	700	100	Continuous
89.0	Mainstem	Velocity	1,200	100	Continuous
	Side Channel	Velocity	2,500	40	Continuous
89.5	Mainstem	Velocity	1,400	60	Discontinuous
91.0	Mainstem	Velocity	1,700	80	Discontinuous
92.3	Mainstem	Velocity	1,300	110	Discontinuous
93.7	Mainstem	Velocity	3,500	110	Continuous
94.0	Mainstem	Thermal	3,500	20	Discontinuous
95.2	Side Channel	Velocity	2,400	100	Continuous
96.9	Side Channel	Velocity	5,600	150	Discontinuous
97.0	Mainstem	Velocity	1,100	30	Continuous
102.0	Mainstem	Velocity	2,400	100	Discontinuous
102.9	Mainstem	Velocity	600	100	Continuous
103.5	Mainstem	Velocity	1,850	100	Discontinuous
104.1	Mainstem	Velocity	280	70	Continuous
104.5	Mainstem	Velocity	1,700	110	Continuous
104.9	Mainstem	Velocity	900	150	Continuous
105.9	Mainstem	Velocity	1,050	100	Continuous
106.1	Mainstem	Velocity	200	60	Continuous
106.4	Mainstem	Velocity	370	50	Continuous
106.6	Mainstem	Velocity	350	50	Discontinuous
107.4	Mainstem	Velocity	200	50	Continuous
109.1	Mainstem	Velocity	550	100	Discontinuous
110.3	Mainstem	Velocity	150	100	Discontinuous
110.5	Mainstem	Velocity	290	50	Continuous
110.9	Mainstem	Velocity	450	50	Discontinuous
111.5	Mainstem	Velocity	1,600	100	Continuous
111.7	Mainstem	Velocity	500	90	Continuous
111.9	Mainstem	Velocity	900	150	Continuous
112.5	Mainstem	Velocity	700	100	Discontinuous
112.9	Mainstem	Velocity	500	110	Continuous
113.8	Mainstem	Velocity	600	110	Continuous
117.4	Mainstem	Thermal	780	60	Continuous
117.9	Side Channel	Thermal	1,260	120	Discontinuous
119.6	Side Channel	Thermal	550	50	Continuous
119.7	Mainstem	Velocity	350	50	Continuous

TABLE 4.9 (Continued)

Location of Upsteam End River Mile #	Channel Type	Velocity or Thermal	Approx. Length (Ft)	Widest Point (Ft)	Continuous or Discontinuous
120.3	Mainstem	Velocity	800	100	Continuous
121.1	Mainstem	Velocity	550	100	Continuous
121.8	Side Channel	Thermal	1,450	30	Discontinuous
122.4	Slough (7)	Thermal	1,850	60	Discontinuous
122.5	Slough (7)	Thermal	380	50	Continuous
122.9	Slough (7)	Thermal	1,950	80	Discontinuous
123.1	Mainstem	Velocity	1,000	80	Continuous
123.9	Side Channel	Thermal	200	50	Continuous
124.4	Side Channel	Velocity	270	40	Continuous
124.9	Mainstem	Thermal	600	90	Continuous
125.3	Slough (8)	Thermal	3,500	50	Discontinuous
125.5	Mainstem	Velocity	2,140	100	Continuous
125.5	Slough (8)	Thermal	800	500	Continuous
125.6	Mainstem	Velocity	350	60	Continuous
125.9	Slough (8)	Thermal	580	50	Continuous
126.1	Slough (8)	Thermal	500	30	Continuous
126.3	Slough (8)	Thermal	250	50	Continuous
126.8	Slough (8)	Thermal	1,500	80	Discontinuous
127.2	Side Channel	Thermal	2,450	50	Continuous
127.5	Mainstem	Velocity	700	80	Continuous
128.9	Slough (9)	Thermal	5,060	100	Continuous
128.5	Side Channel	Thermal	1,210	30	Discontinuous
128.8	Side Channel	Thermal	380	20	Continuous
129.2	Slough	Thermal	4,000	30	Discontinuous
130.0	Mainstem	Velocity	600	90	Continuous
130.8	Side Channel	Thermal	5,000	50	Discontinuous
130.7	Mainstem	Velocity	150	50	Continuous
131.1	Mainstem	Velocity	490	90	Continuous
131.3	Mainstem	Velocity	800	100	Continuous
131.5	Side Channel	Thermal	5,000	80	Discontinuous
131.3	Side Channel	Thermal	900	90	Discontinuous
132.0	Mainstem	Velocity	150	20	Continuous
132.1	Mainstem	Velocity	500	20	Discontinuous
132.3	Mainstem	Velocity	400	80	Continuous
132.6	Mainstem	Velocity	1,350	80	Continuous
133.7	Slough	Thermal	6,000	60	Continuous
133.7	Mainstem	Velocity	1,110	100	Continuous
134.3	Slough (10)	Thermal	4,500	40	Continuous
134.0	Side Channel	Thermal	1,200	50	Continuous
134.5	Side Channel	Thermal	850	100	Continuous
135.2	Mainstem	Velocity	1,580	90	Discontinuous

TABLE 4.9 (Continued)

Location of Upsteam End River Mile #	Channel Type	Velocity or Thermal	Approx. Length (Ft)	Widest Point (Ft)	Continuous or Discontinuous
135.7	Slough (11)	Thermal	5,500	80	Continuous
136.0	Mainstem	Velocity	230	80	Continuous
136.3	Side Channel	Thermal	2,050	40	Continuous
136.7	Mainstem	Thermal	1,620	80	Continuous
137.1	Mainstem	Velocity	750	60	Continuous
137.4	Side Channel	Thermal	2,500	20	Discontinuous
137.8	Slough (16)	Thermal	1,400	30	Discontinuous
138.2	Mainstem	Velocity	2,000	150	Continuous
138.9	Mainstem	Thermal	2,100	150	Continuous
139.0	Mainstem	Velocity	780	20	Continuous
139.1	Mainstem	Velocity	500	30	Continuous
138.4	Mainstem	Velocity	600	30	Continuous
140.6	Side Channel	Thermal	1,900	100	Discontinuous
	Slough (20)	Thermal	1,100	20	Continuous
142.0	Slough (21)	Thermal	3,850	40	Discontinuous
141.5	Mainstem	Velocity	850	40	Continuous
142.0	Mainstem	Velocity	950	50	Continuous
142.6	Mainstem	Velocity	1,600	150	Discontinuous
142.8	Mainstem	Velocity	850	150	Continuous
143.6	Mainstem	Velocity	550	20	Discontinuous
	Mainstem	Velocity	280	20	Continuous
143.8	Mainstem	Velocity	780	100	Continuous
143.9	Mainstem	Velocity	500	30	Continuous
144.5	Mainstem	Velocity	900	100	Discontinuous
	Slough (22)	Thermal	250	20	Continuous
144.6	Slough (22)	Thermal	300	20	Continuous
145.5	Mainstem	Velocity	1,150	100	Continuous
146.9	Mainstem	Velocity	700	100	Continuous
147.1	Mainstem	Velocity	850	80	Discontinuous
147.7	Mainstem	Velocity	150	40	Continuous
148.1	Mainstem	Velocity	420	50	Discontinuous
148.5	Mainstem	Velocity	680	140	Continuous
149.0	Mainstem	Velocity	400	60	Continuous
149.5	Mainstem	Velocity	500	80	Continuous
150.0	Mainstem	Velocity	350	20	Discontinuous
150.2	Mainstem	Velocity	750	100	Continuous
151.2	Mainstem	Velocity	2,800	100	Discontinuous

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ICE CONCENTRATIONS AT TALKEETNA RELATIVE TO MEAN DAILY AIR TEMPERATURES AT DENALI AND TALKEETNA AND DAILY TOTAL SNOWFALL AT TALKEETNA

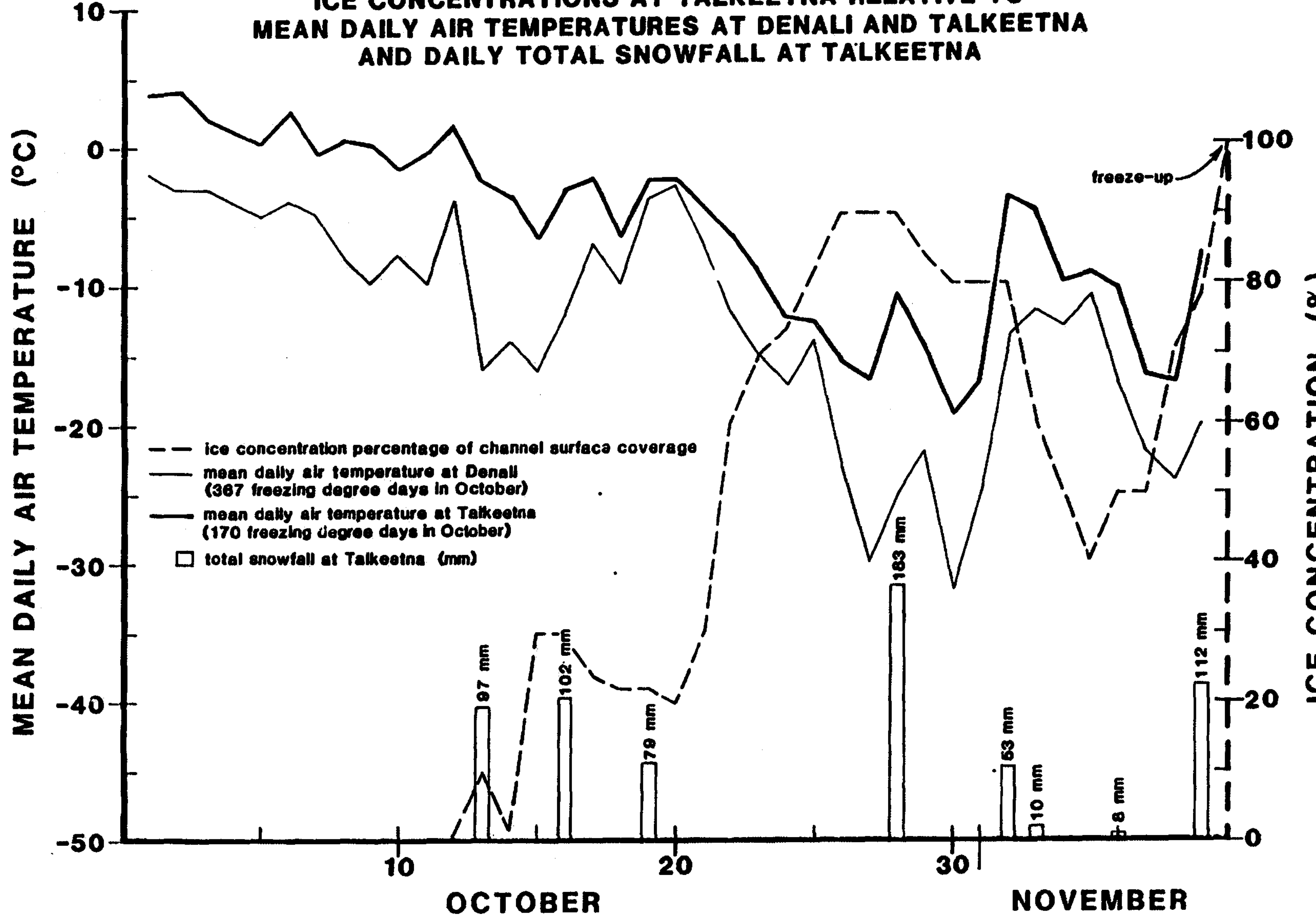

Figure 4.1

HARZA-EBASCO
SUSITNA JOINT VENTURE

ICE CONCENTRATIONS AT GOLD CREEK RELATIVE TO MEAN DAILY AIR TEMPERATURES AT DEVIL CANYON AND DAILY TOTAL SNOWFALL AT GOLD CREEK

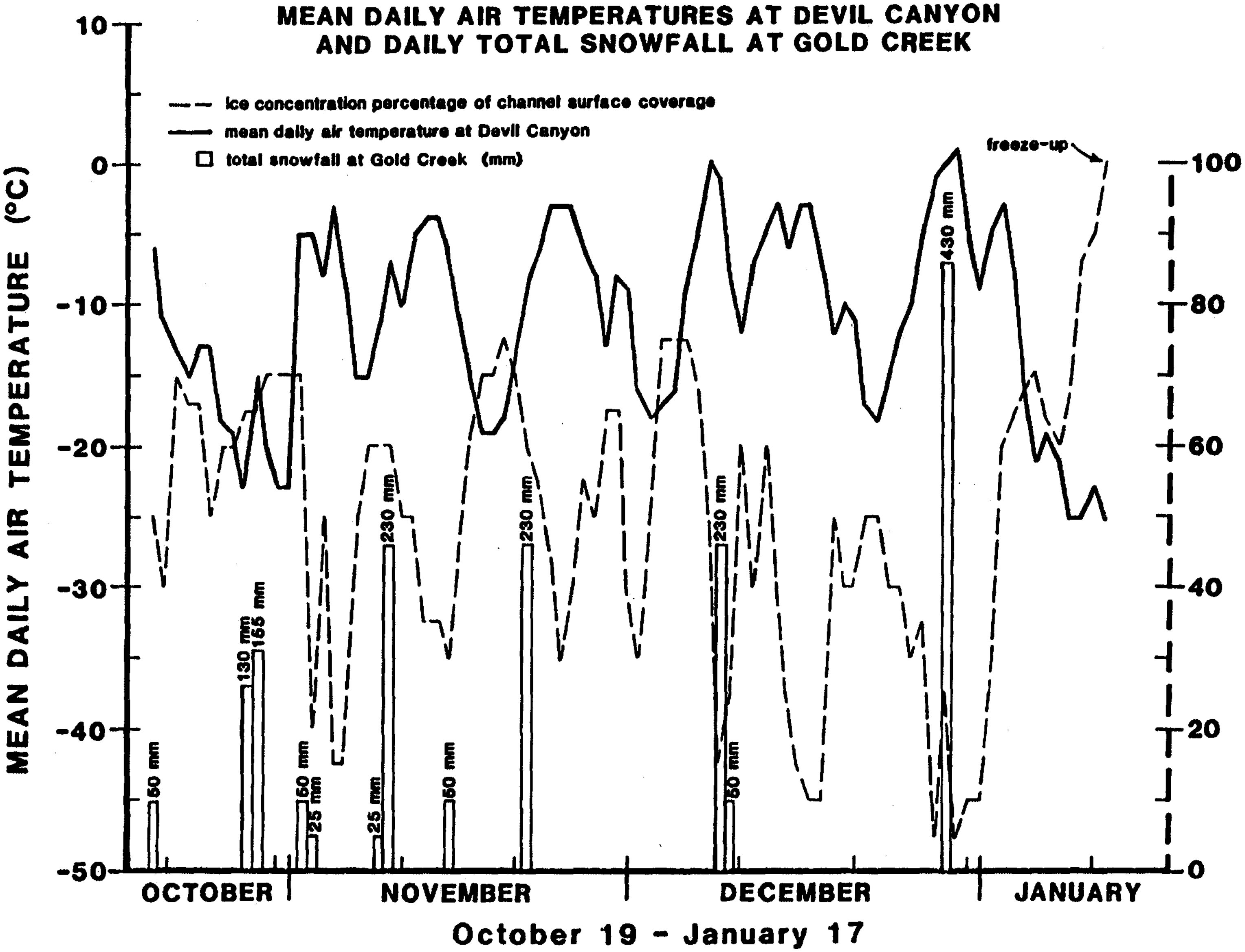

Figure 4.2

HARZA-EBASCO
SUSITNA JOINT VENTURE

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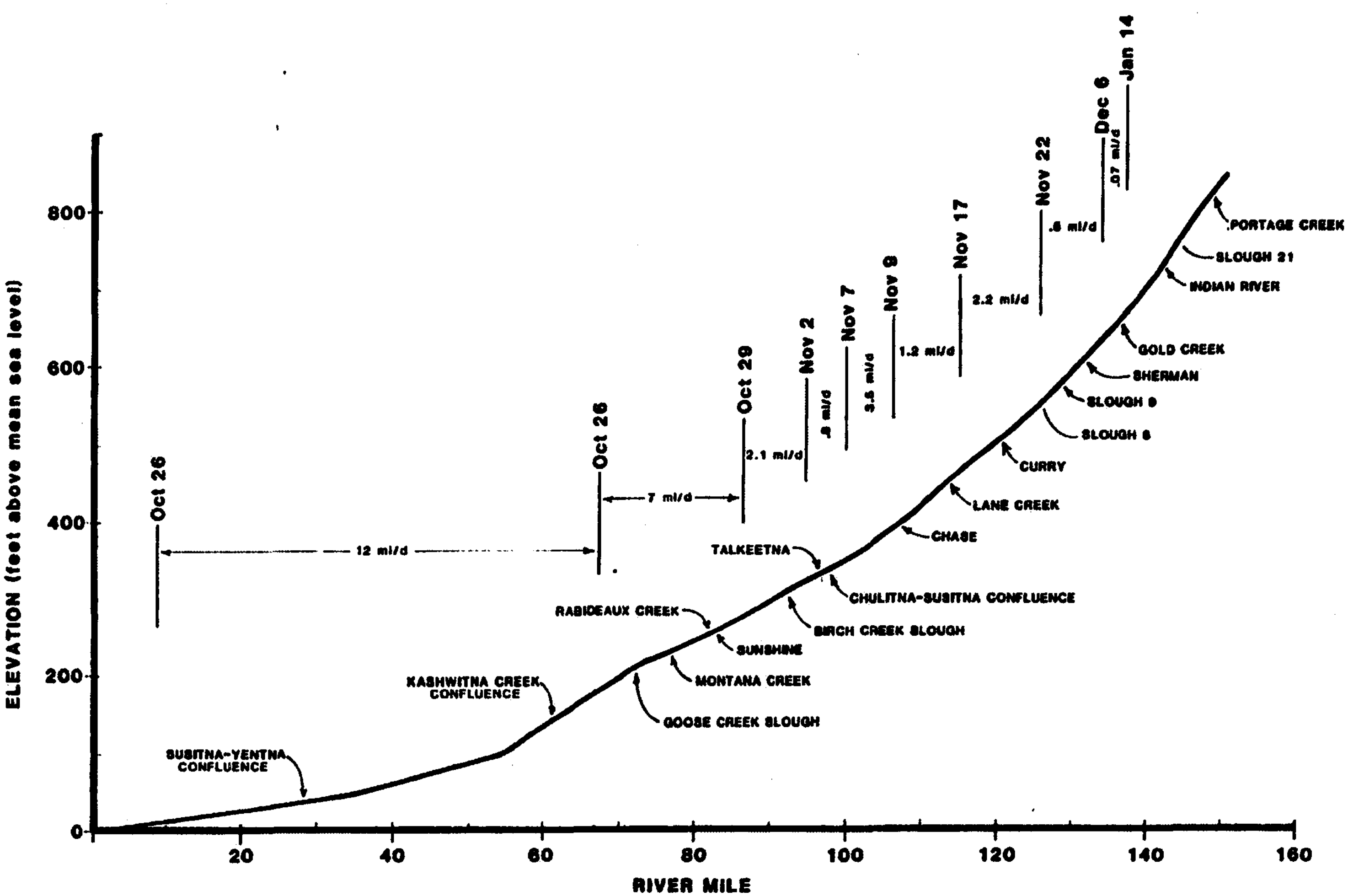

SUSITNA RIVER ICE LEADING EDGE PROGRESSION RATES (miles/day) RELATIVE TO THE THALWEG PROFILE FROM RIVER MILE 0 (Cook Inlet) TO RIVER MILE 155

Figure 4.3

HARZA-EBASCO
SUSITNA JOINT VENTURE

STAGE FLUCTUATIONS IN GROUND WATER WELL 9-1A (River Mile 129.5) RELATIVE TO MAINSTEM DISCHARGE

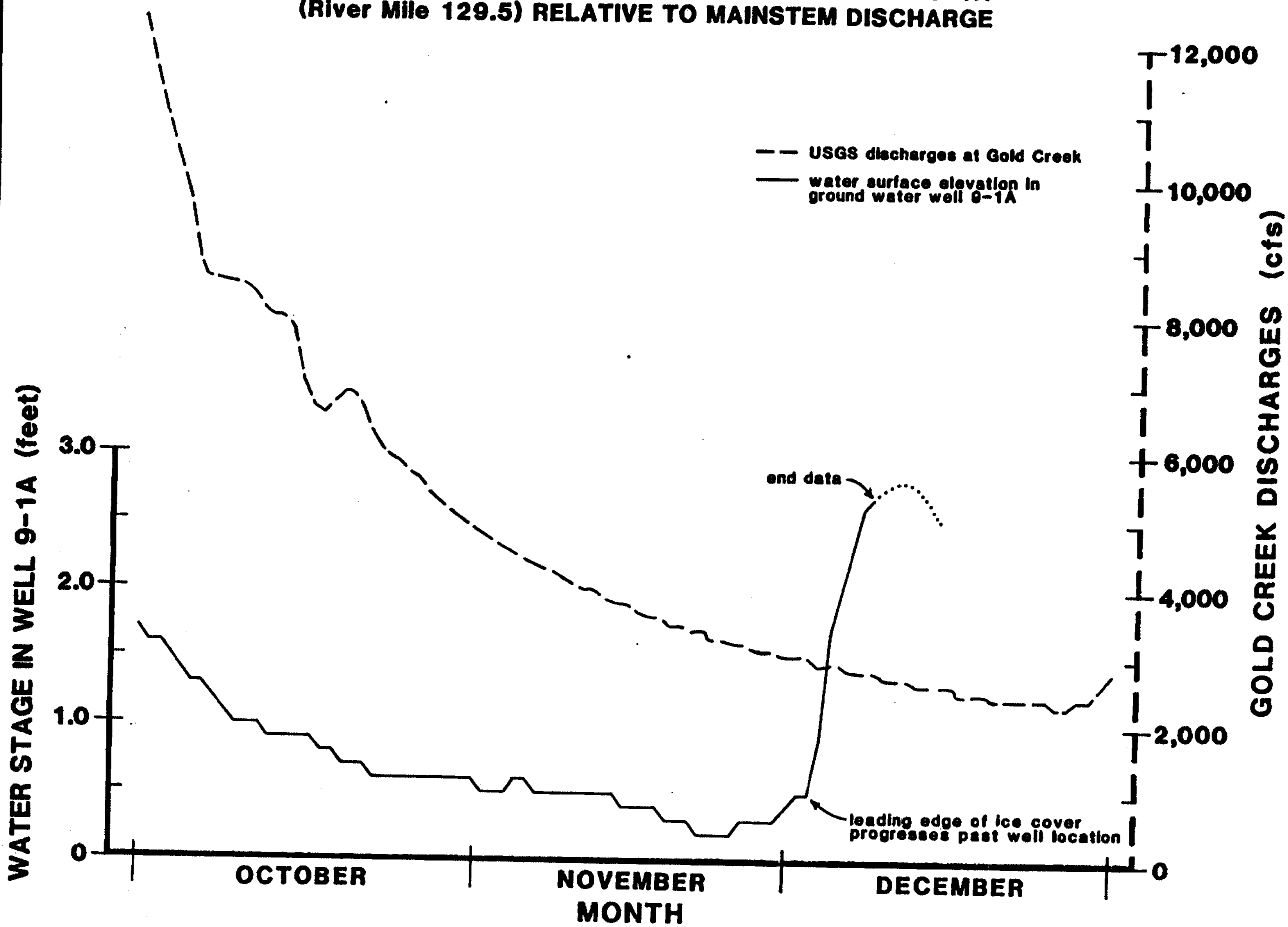

Figure 4.4

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HARZA-EBASCO
SUSITNA JOINT VENTURE

TIME LAPSE CAMERA LOCATION AT DEVIL CANYON

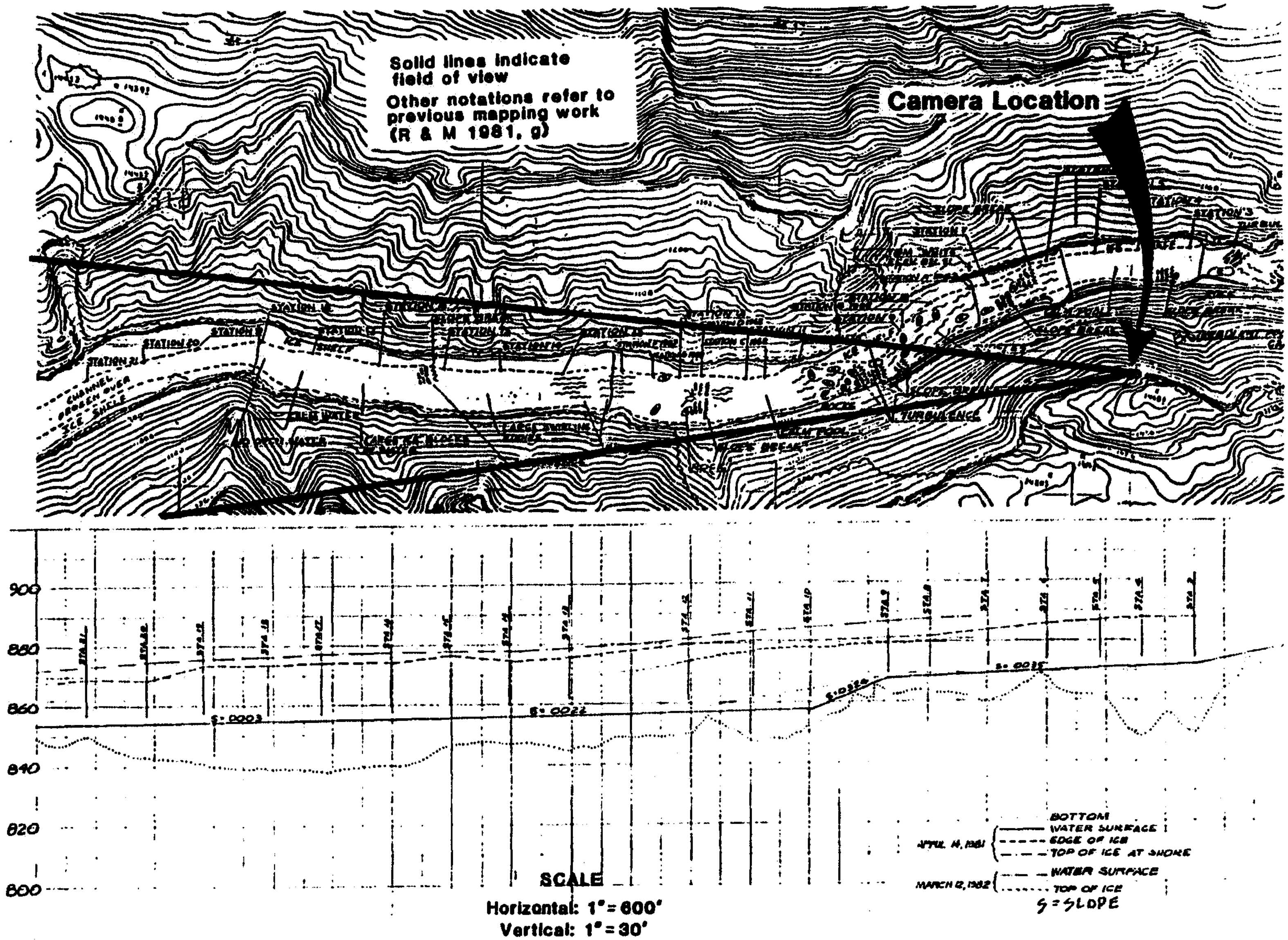

Figure 4.8

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SUSITNA JOINT VENTURE

s8/w1

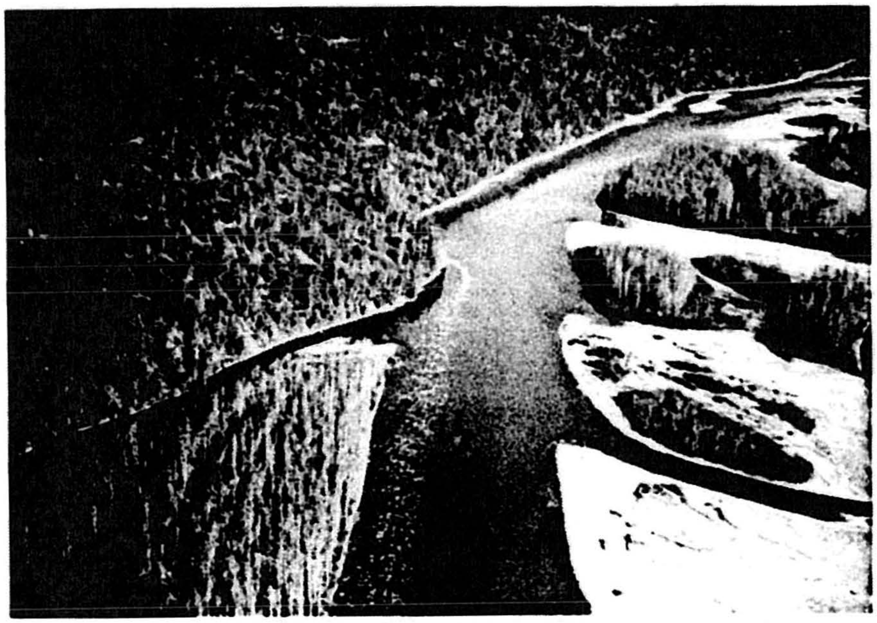

PHOTO 4.1

Ice plume near Slough 9, flowing towards bottom of photo. Frazil ice can form in September on the upper Susitna River between Denali and Vee Canyon where air temperatures are generally much colder than near Talkeetna. These ice plumes are often the first indicators of frazil formation.

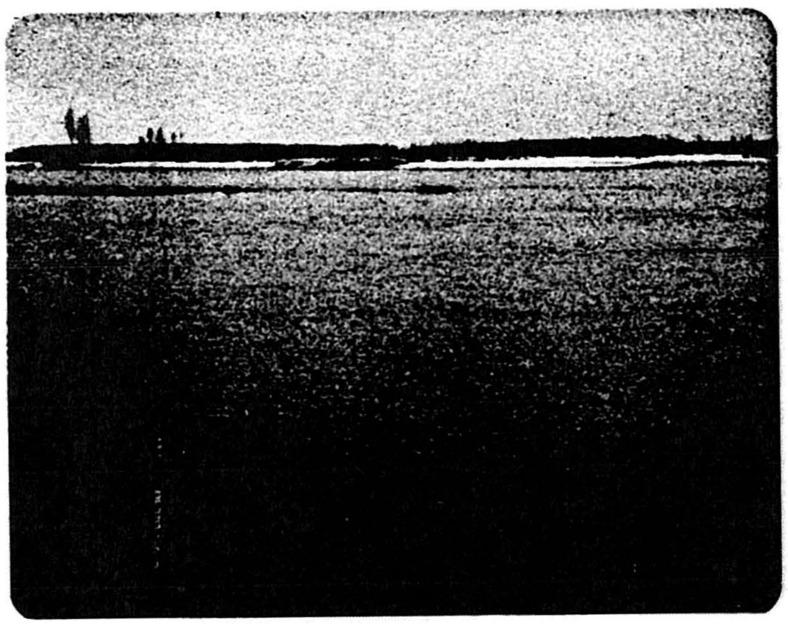

PHOTO 4.2

View of the mainstem, adjacent to the town of Talkeetna, on October 12, 1982. Flow is from right to left. Note staff gage in foreground. Water level reads 1.65 feet.

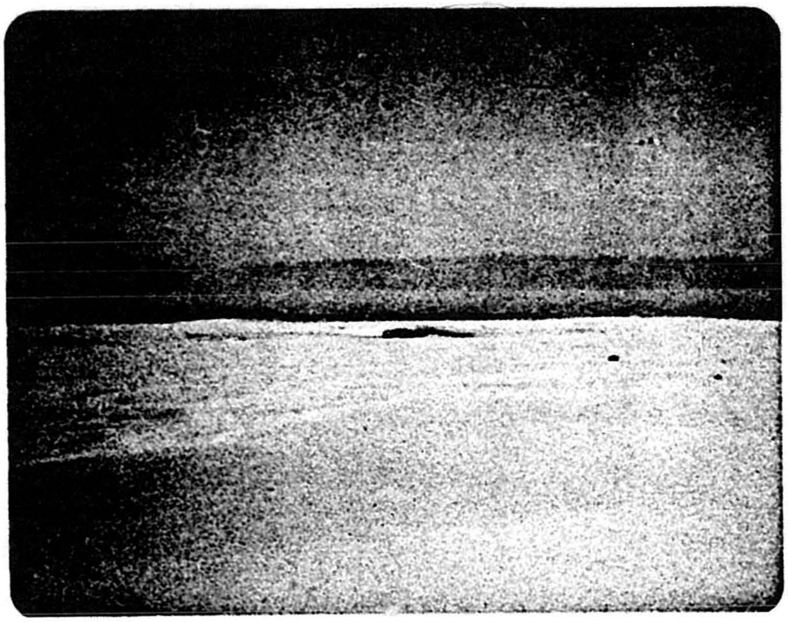

PHOTO 4.3

View of the mainstem, adjacent to the town of Talkeetna, on October 30, 1982. The water level dropped over 3 feet since October 12, exposing the gravel bar in the foreground. The photo was taken 5 days before the ice front passed Talkeetna. By November 7, this area was covered by 4 feet of ice.

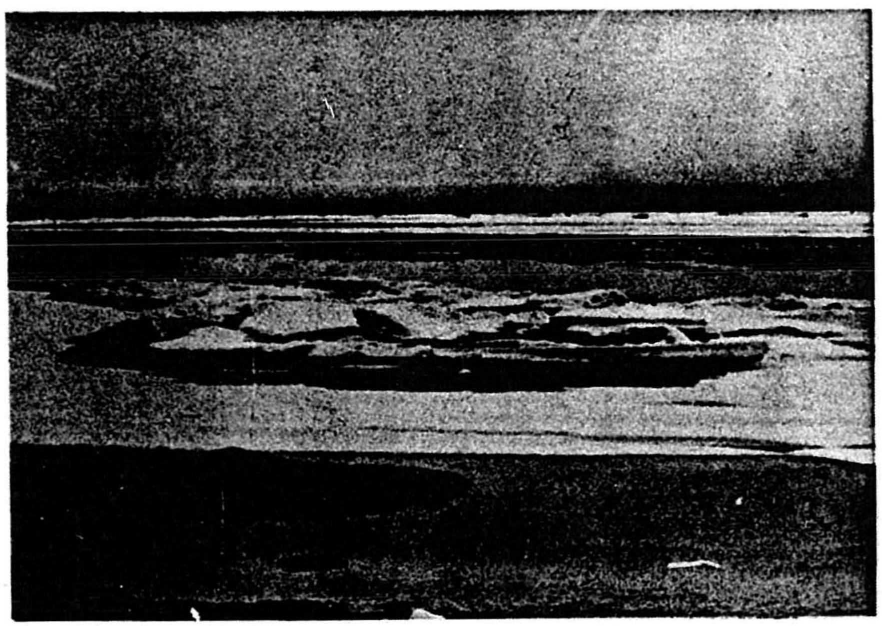

PHOTO 4.4

View of the mainstem, adjacent to the town of Talkeetna, on November 4, 1982. The ice front has progressed to within 1 mile of this area, and caused the water level to increase over 2 feet. The shore ice in the foreground has fragmented and will eventually wash away.

s8/w3

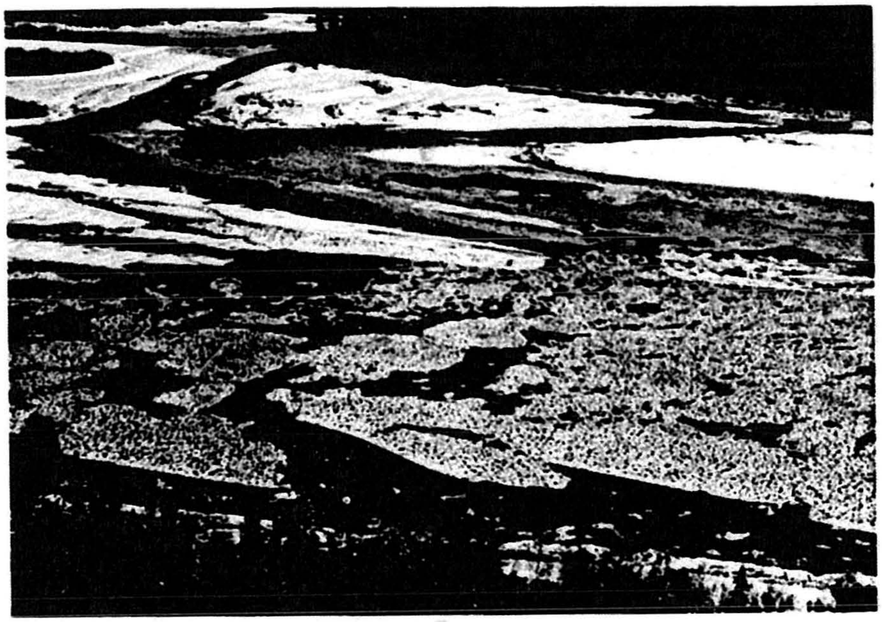

PHOTO 4.5

Slush ice accumulating by juxtaposition on October 29, 1982 at Sunshine. Flow is from left to right. This area represents the leading edge of an ice front that has just passed the Parks Highway Bridge. Note the flooded side channel in the upper photo. The ice pack has caused a local increase in water level of about 2 feet.

PHOTO 4.6

Shore ice constriction near Slough 9 on October 26, 1982. Flow is from right to left. Note the successive layers of slush ice that have built up along the left bank. Slush ice is being compressed through the surface constriction, emerging on the left as rafts.

PHOTO 4.7

Shore ice constriction in Devil Canyon on October 21, 1982. Flow is from right to left. Shore ice constricts the surface flow, often concentrating frazil slush into a layer that fragments downstream into pans and rafts. Note the absence of floating ice upstream of the constriction.

PHOTO 4.8

Ice bridge in Devil Canyon on October 21, 1982. This closure represents the first ice cover on the Susitna above Talkeetna. Flow is from left to right. The initial constriction by shore ice is still evident. Channel configuration is shallow gradient and gravel bar on the right bank and deep narrow thalweg along the left bank.

s8/w5

PHOTO 4.9

View of the Chulitna confluence with the Susitna mainstem, looking upstream on October 29, 1982. The Chulitna west channel enters in the left foreground, the east channel comes in on the upper left, and the Susitna River flows diagonally from the center to the right margin. Note the slush ice accumulation at the east channel.

PHOTO 4.10

Susitna River confluence with the Chulitna east channel on November 2, 1982, view looking downstream on the Susitna. The slush ice constriction at the confluence has consolidated and frozen, creating this jam and causing subsequent flooding. About 1000 cfs is being diverted into the Chulitna east channel. Compare with photo 11.

s8/w6

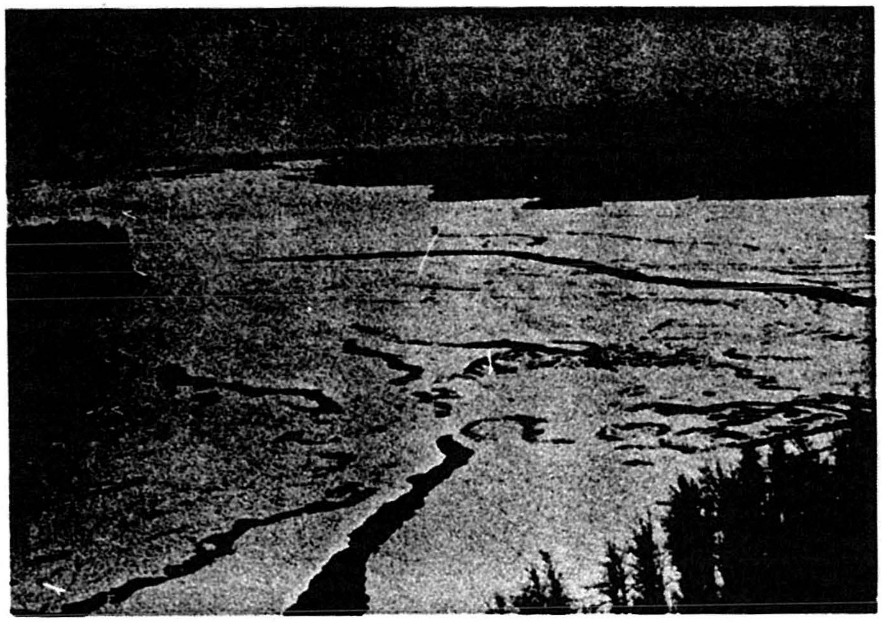

PHOTO 4.11
Susitna River confluence with the Chulitna, view looking downstream on November 9, 1982. The Susitna is ice covered and the Chulitna east channel, flowing from right to left, appears as an open lead in the center. The left end of the lead intersects the Susitna ice cover.

PHOTO 4.12
The Susitna River at river mile 99.6 looking upstream on November 2, 1982. The river thalweg runs diagonally from the lower right to the upper left of the photo. At river mile 101.3, near Whiskers Creek, about 1,200 cfs was diverted into the side channel on the right.

s8/w7

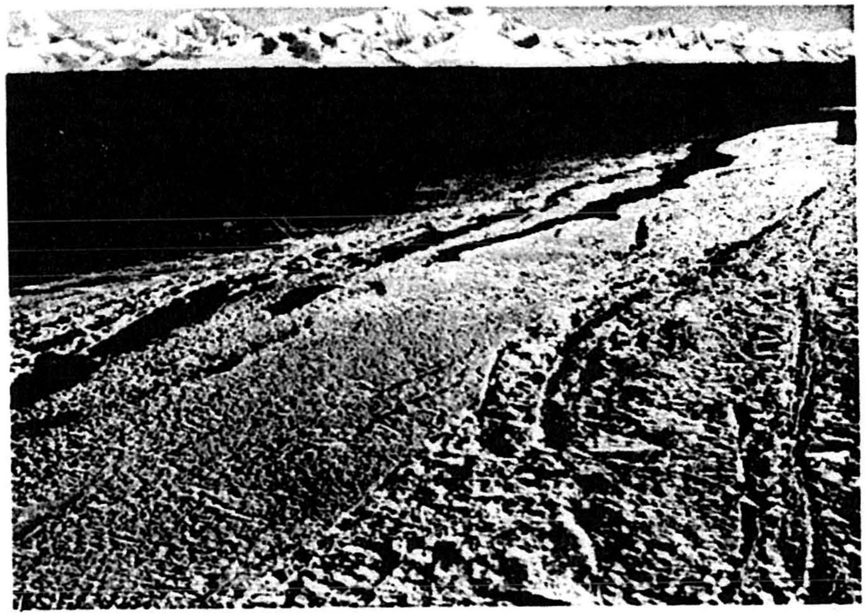

PHOTO 4.13

Susitna River at river mile 106 on November 17, 1982. Flow is from the upper right to lower left. Ice cover has telescoped to cover the river channel from bank to bank. Note the sagging ice cover over the narrow winter channel and the open leads created by turbulent flow.

PHOTO 4.14

Open leads on February 2, 1983 at river mile 103.5, view looking downstream. Note the slush ice cover developing in the foreground.

s8/w8

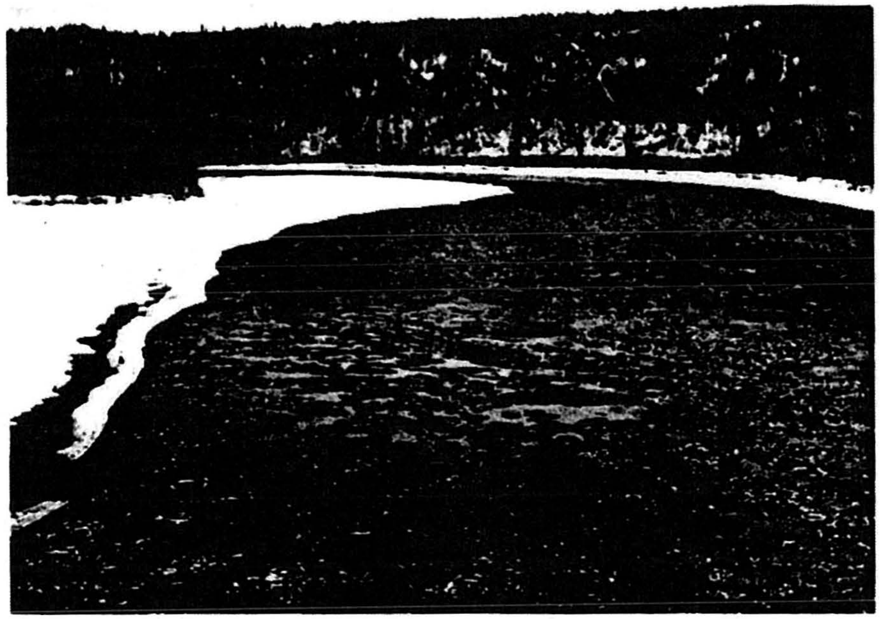

PHOTO 4.15
Susitna River at Gold Creek on October 16, 1982, looking downstream from the railroad bridge. Note the frazil slush floes and shore ice development.

PHOTO 4.16
Susitna River at Gold Creek on January 13, 1983. Shore ice development has constricted the water surface width to less than 50 feet under the bridge. The ice cover progressed past Gold Creek on January 14.

s8/w9

PHOTO 4.17
Sample of ice taken during breakup at river mile 142. Dense concentrations of anchor ice were observed through this reach during freeze-up. This ice had accumulated sediment by filtration and entrapment of saltating particles.

PHOTO 4.18
Extensive shore ice development near the confluence of Devil Creek. Flow is from left to right. Shore ice had built out in successive layers to constrict the channel until slush ice could no longer flow through.

PHOTO 4.19
View looking upstream at river mile 104 on February 2, 1983. The ice cover has settled onto the channel bottom except where open leads persist.

PHOTO 4.20
Time lapse camera mounted on the south rim of Devil Canyon near the proposed damsite. This camera filmed the ice cover development in the canyon from October 21, 1982 until February 7, 1983.

5.0 SUSITNA RIVER BREAKUP PROCESSES

Destruction of a river ice cover progresses from a gradual deterioration of the ice to a dramatic disintegration which is often accompanied by ice jams, flooding, and erosion. The duration of breakup is primarily dependent on the intensity of solar radiation and the amount of rainfall. An ice cover will rapidly break apart at high flows. Ice debris accumulates at flow constrictions and can become grounded. The final phases of breakup are characterized by long open reaches separated by massive ice jams. A large jam releasing upstream will usually carry away the remaining downstream debris leaving the river channel virtually ice free.

5.1 Ice Cover Deterioration

Initial phases of ice cover deterioration commonly occur by mid-April. These are identified by flooded snow and overflow on ice and can be attributed to a slight increase in discharge. The rise in water level is generally associated with moderating air temperatures and the increasing daily duration of solar radiation. Solar radiation can cause snow to melt even though air temperatures remain below freezing.

Overflow takes place because the rigid and impermeable ice cover fails to respond to water level fluctuations (Table 5.1). Increasing stage results in immediate and severe erosion at the ice/water interface. Where the ice is continuous and unbroken, standing water commonly appears in the sags and depressions. This water substantially reduces the albedo of the ice surface and generally, within days, an open water lead develops in these depressions. With water levels rising steadily, the channel perimeter expands and undercutting of the stranded ice begins. This causes portions of the ice cover to hang over the flowing water of the open lead. When the critical shear stress is exceeded, portions of the ice cover collapse by either hinging at the point where it contacts the bottom or by shearing vertically from the main ice body. The ice fragments then drift downstream to accumulate with other floes against the solid ice cover at the downstream edge of the lead. By this process, open leads gradually become wider and longer.

The high velocity reaches in which most leads form are more common above Talkeetna because the river channel is relatively narrow, lacks a wide flood plain, and has a steeper gradient. Downstream from Talkeetna, the broad and shallow river channel has less gradient and tends to reduce velocities by dissipating the flow over a wider area. Here open leads occur less frequently and the first indicator of rising water levels is extensive overflow. On April 7, 1983 an area of overflow near the Parks Highway Bridge covered the ice sheet with over half a foot of flowing water. The ice cover in this section was a composite of porous slush ice floes that had consolidated during freeze-up and consisted of coarse, rounded ice crystals. Because of its loosely-packed crystal configuration, the ice cover was permeable to water and lacked sufficient buoyancy to break loose from the shore-fast ice and float, so it remained submerged until eventually melting away.

Solid and continuous ice covers can fragment en masse when the pressure created by the rising water level can no longer be contained, this was especially on the lower river downstream of Talkeetna. The shattered ice cover, however, will remain in place for several days if the ice downstream remains intact.

During April, solar radiation generally increases in intensity and duration. Early in the month, warming air temperatures usually begin to affect the snowpack in the lower elevations near Susitna Station causing it to quickly turn isothermal and melt. By late April, the snowpack has disappeared from the river downstream of Talkeetna and has started to melt in areas along the upper river, especially on south facing slopes. The snow laying on the river ice cover is often relatively thin compared to the snowpack covering the ground because of exposure to higher winds which can rapidly ablate the snow or simply blow it away. In addition, overflow can cause a dramatic reduction of the snow thickness by consolidating and changing the snow crystal structure into ice. On many reaches of the river, the snow cover has been observed to disappear from the river ice while a deep snowpack remains along the banks.

Once the snow cover over the river ice melts, solar radiation rapidly disintegrates the crystal structure of the ice. Disintegration of the ice cover by incident solar radiation is commonly indicated by the process of "candling." This phenomena results from a structural failure along the individual crystal boundaries. When ice crystals grow, impurities in the water are expelled from the crystal structure and tend to become concentrated along the crystal edge and at crystal boundaries. Ice crystals generally prefer to grow perpendicular to the c-axis and parallel to the thermal gradient. Simultaneous growth of adjoining crystals prevents much widening and the characteristic long, narrow, six-sided crystals result. The effects of solar radiation are accentuated at the weak crystal boundaries and melting occurs here. This process begins at the ice surface and can extend through the total thickness of the ice sheet. Candling significantly weakens the ice which during advanced stages of disintegration can shatter on impact into splintered masses of individual crystals.

Observations of ice sheet fragmenting during the 1983 breakup on the Susitna River revealed a tremendous resistance by the ice to any form of horizontal shearing. The peculiar resistance to horizontal shear can be explained by the configuration of the crystal structure. The hexagonal crystals fit together in a compact arrangement that eliminates horizontal sliding surfaces between individual crystals. In the vertical direction, however, each crystal boundary represents a sliding surface and every candled crystal will readily shear away from its neighbor. The significance of this phenomenon is evident during breakup when tremendous horizontal shear stresses created within massive ice jams often fail to fragment ice sheets at the jam key. However, the stage increases associated with ice jams appear to easily snap loose huge sheets of border ice. On a smaller scale, gradually increasing mainstem discharges continually cause shorefast ice along the flow margins to break away by vertically shearing along ice crystal boundaries.

By the end of April, 1983, the Susitna River was laced with long, narrow open leads. Floes that had fragmented from the ice had accumulated into small ice jams. The configuration of these small ice jams often resembled a U or V-shaped wedge, the apex of the wedge corresponding to the highest velocities in the flow distribution. The constant pressure exerted by these wedge-shaped ice jams effectively lengthened and simultaneously widened many open leads. This process of widening the surface area is particularly significant because any ice floes drifting downstream consequently had a clear passage, greatly reducing the potential of ice lodging and creating a major jam.

5.2 Ice Jams

Based on historical events and morphologic evidence, several of the small, open lead ice jams were expected to develop into major jams. Examination of mainstem cross sections adjacent to side channels and sloughs indicated a striking similarity of channel configurations at suspected jam keys. Most of the cross sections in these areas consisted of a broad channel with gravel islands or bars and a narrow, deep thalweg, possibly representing an ice scour hole, confined along a rock wall or along one of the banks. The presence of sloughs on a river reach may also indicate the locations of major recurring ice jam events. Many of the sloughs on the Susitna River between Curry and Devil Canyon were carved through terrace plains by some extreme flooding event. Summer floods, although frequently flowing through sloughs, do not generally result in water levels high enough to overtop the river bank. During breakup, however, ice jams commonly cause rapid, local stage increases that generally continue rising until either the jam releases or the sloughs are flooded. If the sloughs did not exist, then water levels would increase until the capacity of the channel was exceeded and the water would flow laterally out of the mainstem. The flow would probably also carry with it a great volume of ice which could easily erode first the soils and gravels of the terrace plains. Water would continue flooding the overbank until the jam decayed. When no terrace plain adjoins a mainstem ice jam, then stages would increase to a level that created unstable conditions at the jam key, forcing the jam to release. It seems, therefore, that on the Susitna, sloughs are an indicator of frequent ice jamming on the adjacent mainstem and can also influence the stability and longevity of these jams by relieving the stage increases and subsequent water pressures acting against the ice.

In May of 1976 during an extreme ice jam event at river mile 135.9, the river not only flooded the adjacent bypass channel but also carved out what is now identified as Slough 11. Photo 46 is a photograph, taken from the Gold Creek railroad bridge on May 7, 1976, showing a substantial volume of water flowing through Slough 11. The mainstem and bypass channel are towards the right of the photo and appear to be completely ice choked. Local residents have indicated that this event created most of Slough 11. Several ice jams of smaller magnitude since 1976 have also breached the berm at the channel head and enlarged the slough to its present configuration.

The following channels between Devil Canyon and Gold Creek, are regularly influenced by ice induced flooding during breakup:

Slough 22
Slough 21 from RM 142.2 to RM 141
Slough 11 from RM 136.5 to RM 134.5
Side channels from RM 133.5 to 131.1
Side channels from RM 130.7 to 129.5
Slough 9
Slough 8A and 8
Slough 7

In general, the final destruction of the ice cover is accomplished by a series of ice jams which break in succession and are added to the next jam. This mass of ice continues building as it moves downstream. Upstream from this accumulation, the river channel is commonly ice free except for stranded ice floes and some drifting ice coming from above Devil Canyon.

Ice studies during the 1983 Susitna River breakup were oriented towards acquiring ice jam profiles on the river reach between Talkeetna and Devil Canyon as well as quantitative data on ice thicknesses, staging, and flow velocities (Figure 5.1 and Tables 5.1 to 5.4. The specified reach was chosen because of its normally dramatic breakup and potential for massive ice jam formations. Measurements were initially taken twice daily at specific sites known to be affected by ice jams. Water surface elevations, ice thicknesses, and ice cover erosion rates were measured through bore holes. Velocities in the mainstem above and below ice jams were successfully measured by suspending an electronic sensor with 30 feet of wire cable from a helicopter and obtaining a spot reading at 2 feet below the water surface. The water depth both above and below jams was also often measured by reading the depth directly from metal flags attached to the cable which was kept vertical with a 50 lb. lead weight. These data are presented in Table 5.1.

The major streams flowing directly into the lower Susitna River were contributing substantial discharges by April 27, 1983. The ice was in varying stages of decay on these tributaries, with Kashwitna Creek retaining a virtually intact ice cover, and Montana Creek, Sheep Creek, and Willow Creek breaking up rapidly. Observation during an aerial reconnaissance on April 29 documented a rapidly disintegrating mainstem ice cover from Talkeetna down to the Montana Creek confluence. Further downstream, the mainstem ice cover was extensively flooded but remained intact. Above the Parks Highway Bridge the ice cover and shattered into large ice sheets in several areas. The large size of these fragments however, prevented the ice from flowing out. At Sunshine, an ice covered reach was flooded by about 1 foot of overflow and yet remained intact. No ice jams had occurred.

Observers at Susitna Station reported ice beginning to move downstream on May 2 with flowing ice continuing to pass for several days (Table 5.2). Deshka River residents observed the first ice moving on May 4 and the steady ice flows ending on May 10 (Table 5.3). No significant jams were noted. This indicates an upstream progression of ice breakup which confirmed the aerial observations on the river below Montana Creek.

On May 4, 1983, two relatively small ice jams fromed at RM 85.5 and RM 89. The jam keys were small, however even the minimal staging that resulted caused extensive flooding of the surrounding gravel and sand flood plain. Many logs were set adrift appearing to cause damage but most of these logs had previously been stranded by high summer flows.

The largest ice jam observed on the lower river occurred on May 5 near the confluence with Montana Creek at RM 77. Here an extensive accumulation of drifting ice debris had failed to pass around a river bend and jammed. The Montana Creek confluence was flooded but no damage or significant impact by ice or water was noted. Although the lower river reach had been essentially ice free since May 6, drifting ice released from the upper river was continuing to jam.

Residents at Susitna Station, the Deshka River confluence, and Gold Creek provided additional measurements of water levels and ice thicknesses as well as qualitative descriptions of the sequence of events leading up to ice-out. Weekly aerial reconnaissance flights were conducted in order to document the interrelationship between river reaches. Tables 5.1 to 5.4 at the end of this section present all pertinent information. The following description is a chronological sequence of breakup events on the upper river from April 27 to May 10, 1983.

On April 27, 1983, daily observations and data acquisition began. By this time, the river had already been opened wide in some areas by the downstream progression of small ice jams. These minor ice floe accumulations remained on the water surface, often breaking down any intact ice cover obstructing their passage. As described earlier, this process is initiated in open leads which gradually become longer and wider until extensive reaches of the channel are essentially ice free. These small ice jams may be important in preventing the occurrence of larger, grounded ice jams. This was evident in 1983 when large ice jams released, sending tremendous volumes of floating ice downstream. The small jams had provided wide passages for the flowing ice which may have jammed again if the channel had remained constricted. On April 27, extensive channel enlargements and small ice jams were steadily progressing downstream near the following locations:

Portage Creek, RM 148.8
Jacklong Creek, RM 145.5
Slough 21, RM 142.0
Gold Creek, RM 135.9
Sherman Creek, RM 131
Curry Creek, RM 120

A large jam had developed near Lane Creek and was apparently grounded. Flooded shore ice surrounding the jam indicated that some water had backed up. A noticeable increase in turbidity occurred on this day. Aerial observations on April 28 revealed an open channel for most of the reach between Talkeetna and Sunshine.

Continuing reconnaissance upstream from Talkeetna on May 1 showed that the ice jam at Lane Creek was still accumulating ice floes. The source of the floes was limited to the fragmenting shore ice and no significant accumulation could occur here until ice jams further upstream released. The Lane Creek jam had progressed about 300 feet downstream since April 27. The ice jam near Slough 21 had increased in size and was raising the water level along the upstream edge. This backwater extended approximately 300 feet upstream. Table 15 shows a relative stage increase at this measurement site of over 3 feet in 24 hours. Figure 10 illustrates the water profile before and after this ice jam occurred.

By May 2, 1983, several significant ice jams had developed. The small ice jam at Gold Creek had broken through the retaining solid ice sheet forming a continuous open channel from RM 139 near Indian

River to a large ice jam at RM 134.5. The small ice jam that had been fragmenting the solid ice at the downstream end of an open lead adjacent to Slough 21 had progressed down to RM 141. A large jam had developed at RM 141.5 leaving an open water area between the two jams. The upstream ice jam was apparently created when a massive ice sheet snapped loose from shore-fast ice and slowly pivoted out into the mainstem flow, maintaining contact with the channel bottom at the downstream left bank corner. This sheet was approximately 300 feet in diameter and probably between 3 and 4 feet thick. The upstream end continued to pivot around until it contacted the right bank of the mainstem. The ice sheet was then in a very stable position, jammed against the steep right bank and grounded in shallow water along a gravel island on the left bank. Several small ice jams upstream of Slough 21 had released and were accumulating against this ice sheet extending the jam to a total length of about one half mile. The water level had risen and an estimated 2,000 cfs was flowing around the upstream end of the gravel island at RM 142 and into a side channel. The entrance berm to Slough 21 at cross section H9 was also overtopped. This illustrates the extreme staging effects of the jams as the estimated discharge at Gold Creek on this day was less than 6,000 cfs while the normal summer flows required to breach this berm are in excess of 20,000 cfs. The entrance channel at cross section A5 was breached and about 150 cfs was diverted into the lower portion of Slough 21. Many ice floes also drifted through this narrow access channel and were grounded in the slough as the flow dissipated over a wider area.

By May 4, 1983, stable ice jams had developed and were gradually building mass at the following locations between Talkeetna and Devil Canyon:

Lane Creek at RM 113.2
Curry at RM 120.5 and RM 119.5
Slough 9 at RM 129
Slough 11 at RM 134.5
Slough 21 at RM 141.8

Downstream from the ice jam at Lane Creek, the ice cover was still intact although extensively flooded. Between Lane Creek and Curry, the channel was wide open and ice free with the exception of some remnant shore ice. From Curry upstream to the ice jam adjacent to Slough 7 some portions of the ice cover remained, but were severely decayed and disintegration seemed imminent. An intact ice cover remained from Slough 8 past Slough 9 to the ice jam at Sherman. This ice cover had many open leads and large areas of flooded snow. Between the remaining ice jams at Sherman, Slough 11 and Slough 21, the mainstem was open.

The jam at Slough 21 was still receiving ice floes from the disintegrating ice cover above Devil Canyon. As ice floes accumulated against the upstream edge of the jam, the floating layer became increasingly unstable. At some critical pressure within this cover, the shear resistance between floes was exceeded, resulting in a chain reaction of collisions that rapidly caused the entire cover to fail. At this point, several hundred feet of ice cover consolidated simultaneously. These consolidation phases occurred frequently during a 4 hour observation period at Slough 21 on May 4. The frequency was dependent on the volume of incoming ice floes. With each consolidation, a surge wave resulted. During one particular consolidation of the entire half mile ice jam, a surge wave broke loose all the shore fast ice along the left bank and pushed it onto an adjacent gravel island. These blocks of shore ice were up to 4 feet thick and 30 feet wide. The zone affected was almost 100 feet long and yet the event lasted only a few seconds. This process is essentially the same as telescoping during freeze-up except that the ice is in massive rigid blocks as opposed to fine frazil slush and is thus capable of eroding substantial volumes of material in a very short time. The ease with which these ice blocks were shoved over the river bank indicates the tremendous pressures that build within major ice jams.

During all of the observed consolidations at Slough 21, the large ice sheet forming the key of the jam never appeared to move or even shift. The surge waves would occasionally overtop the ice sheet, sending smaller ice fragments rushing over the surface of the sheet. Towards the end of the day, the ice sheet was beginning to deform. Incident solar radiation, erosion and shear stresses were rapidly deteriorating this massive ice block and final observations showed it to have buckled in an undulating wave and fractured in places. Observers at the Gold Creek Bridge reported tremendous volumes of ice flowing downstream at 6 p.m. on May 4 indicating that the jam at Slough 21 had released probably about 1 hour earlier.

The ice released at Slough 21 continued downstream unobstructed until contacting the jam adjacent to Slough 11 at river mile 134.5. The sudden influx of ice displaced the mainstem water and caused rapid staging. Water levels increased sufficiently to breach berms and flood the lower portion of Slough 11 adjacent to mainstem river mile 135. The jam key at this site consisted of shore-fast ice constricting the mainstem flow to a narrow channel of no more than 50 feet. Large ice floes, mostly from the original jam at Gold Creek, had lodged tightly in this bottleneck. Pressures appeared to be exerted laterally against the shore-fast ice which inherently is resistant to movement due to the high friction coefficient of the contacting river bed substrate.

On May 5, few significant changes were observed in the ice jams despite warm, sunny weather and constantly increasing discharges from the tributaries to the mainstem.

It was at first thought that when the ice broke at Slough 11 on May 6, it would carry away the ice jam at Sherman and start a sequence that could destroy the river ice cover potentially as far downriver as Lane Creek. This was prevented by an event that actually increased the stability of the jam at Sherman so that it held for several more days. When the ice jam released near Slough 11 and the debris approached the jam at Sherman, it created a momentary surge of the water level. This surge broke loose huge sheets of shore ice which slowly spun out into the mainstem. One triangular ice sheet about 100 feet wide wedged tightly between two extended sheets of shore-fast ice. Ice floes continuing to accumulate against the upstream edge of this wedge exerted tremendous pressures on the obstruction. A pressure ridge rising at least 10 feet above the ice formed along the contact surfaces of the wedge. This ridge consisted of angular fragments and ice candles.

The water level continued to rise as the mainstem channel filled with ice which eventually extended upstream to RM 132.5. The ice jam had lengthened to over 1.5 miles. Flooding quickly occurred on the side channels adjacent to the mainstem and some ice drifted away from the main channel. The volume of water flowing through the side channel was estimated at approximately 2,000 cfs, as the ice jam consolidated and the water level rose, even more water was diverted through the bypass channels. This volume of diverted flow was critical to the stability and duration of the ice jam. Even though the jam increased in size, any additional hydrostatic pressure was relieved by diverting water into the side channels. The entire sequence of events lasted only about 10 to 15 minutes. The water level rose over 1 foot during this time span. Consolidations would occur periodically for the rest of the day but the jam key would never be observed to shift.

Other jams on May 5 were located at:

Slough 9 at RM 129
Slough 7 at RM 122
Curry at RM 120.5
Lane Creek at RM 113

A small jam at RM 126 near Slough 8 consolidated and the resulting surge started a rapid disintegration of the remaining deteriorated ice cover down to the mouth of Slough 8 near Skull Creek. This same surge appeared to have breached the entrance berm to Slough 8. Slough 9 was also flooded by the jam near the head of this channel. The Slough 7 ice jam received some additional floes when the jam at Slough 8 released. This resulted in a gain of ice mass sufficient to cause a rise in water level and flooding at RM 123.

At 6:30 p.m. on May 6, a moving ice mass that stretched from RM 136 to RM 138, with lesser concentrations extending for many more miles upstream, was observed approaching the Sherman ice jam, Unfortunately, the consequences of this on the Sherman jam were not observed. The condition of the floes indicated that this ice originated from above Devil Canyon. The well-rounded floes appeared to be no larger than 1 foot in diameter and were presumably shaped by the high number of collisions experienced in the turbulent rapids through Devil Canyon. Reconnaissance of the river above Devil Canyon on May 6 revealed a mainstem entirely clear of an ice cover. Stranded ice floes and fragments littered the river banks up to the confluence of Fog Creek. In several short reaches from here upstream to Watana, the ice cover remained intact. A large jam had developed near the proposed Watana damsite and extended approximately 1 mile.

The entire river from the Watana Creek confluence down to the Parks Highway was reconnoitered on May 7. The following ice jams persisted:

Key Location	Length
Watana Damsite	1 mile
Sherman, RM 131.5	3.5 miles
Slough 7, RM 122	1 mile
Slough 6A, RM 112.5	2 miles

Downstream from the jam at Slough 6A, the river retained an intermittent ice cover that was severely decayed and flooded. Below the Chulitna confluence, the mainstem was ice free and no ice jams were observed. The reaches between the remaining ice jams were generally wide open. The Curry jam had released overnight and traveled all the way to the Lane Creek jam. Here, the sudden increase in ice mass shoved the entire ice jam downstream about 1 mile where it again encountered a solid but decayed ice cover.

At about 10:30 p.m. on May 8, the ice jam at Sherman released, sending the total 3.5 miles of accumulated ice drifting downstream en masse at approximately 4-5 feet per second. This accumulation of ice, representing many thousands of tons, easily removed the remaining ice jams at Slough 7 and Slough 6A. In addition, the last solid ice cover from Slough 6A at RM 112 down to the Chulitna and Susitna confluence at RM 98.5 was destroyed and replaced by one long, massive ice jam. This jam extended continuously from RM 99.5

to RM 104 and then was interrupted by an open water section up to RM 107. At this point a second ice jam resumed upstream to RM 109.5. This blockage was later measured to be over 16 feet thick in some sections but more commonly was about 13 feet thick. Water seemed to be flowing through the ice jam and in some areas was roiling at the ice surface.

These ice jams released on the night of May 9. Further observations were conducted on May 10 between RM 109 and RM 110. Along this reach, the final ice release had left accumulations of ice and debris stranded on the river banks. When the ice jams released, the ice floes piled up along the margins did not move, probably due to strong frictional forces against the boulder strewn shoreline. This created a fracture line parallel to the flow vector where shear stresses were relieved. The main body of the ice jam flowed downstream leaving stranded ice deposits with smooth vertical walls at the edge of water. These shear walls at RM 108.5 were 16 feet high. The extreme height of the water surface within the ice jam was demarcated by a difference in color. A dark brown layer represented the area through which water had flowed and deposited sediment in the ice pack. A white layer near the surface was free of sediment and probably was not inundated by flowing water.

On May 10, the only remaining ice in the mainstem was on the upper river above Watana. Here an ice jam about 1.5 miles long had developed near Jay Creek.

Ice floes continued to drift downstream for several weeks after the final ice jam at Chase released. As increasing discharges gradually raised the water level, ice floes that had been left stranded by ice jam surge waves were carried away by the current. On May 21, the massive deposits of ice floes, fragments, slush, and debris were still intact near Whiskers Creek and probably would not be washed away until a high summer flow.

The ice breakup of 1983 occurred over a longer time span than in previous years according to historical information and local residents. This is primarily due to the lack of precipitation during the critical period when the ice cover had decayed and could easily and quickly have been destroyed by a sudden, area-wide stage increase. During a year with more precipitation in late April, ice jams of greater magnitude may form and cause substantially more flooding and subsequent damage by erosion and ice scouring.

Several important aspects related to ice jams were observed this year and are summarized here:

1. Scour holes are often indicators of ice jam locations.

2. Ice jams generally occur in areas of similar channel configuration, that is, shallow with a narrow confined thalweg channel along one bank.

3. Ice jams commonly occur adjacent to side channels or sloughs.

4. Sloughs act as bypass channels during extreme mainstem stages, often relieving the hydrostatic pressure from ice jams and controlling the water level in the main channel. Ice jam flooding probably formed the majority of the sloughs between Curry and Gold Creek.

5. Ice jams commonly create surge waves during consolidation which heave ice laterally onto the overbank.

6. Large ice sheets can break loose from shore-fast ice and wedge across the mainstem channel, creating extremely stable jams that generally only release when the ice decays.

s5/gg1

TABLE 5.1

WATER STAGE AND RIVER ICE THICKNESS MEASUREMENTS AT SELECTED MAINSTEM LOCATIONS

	Ice Thickness (ft)	Surface Elevation[1] (ft)	Top of Ice Elevation[1] (ft)	Velocity[3] ft/sec
April 27, 1983				
Gold Creek Discharge:				
Observed[2] = 4300 cfs				
USGS = 2700 cfs				
Portage Creek	-	832.54	-	5.2
Slough 21, LRX-57	-	749.69	755.50	2.1
Slough 21, LRX-54	3.06	732.21	733.31	2.6
Gold Creek	-	682.04	-	4.6
Slough 11, Mouth	-	[1.11]	[3.30]	4.3
Slough 9, Sherman	-	617.18	-	1.1
Slough 9, Mouth	2.16	[5.74]	[5.73]	-
April 28, 1983				
Gold Creek Discharge:				
Observed[2] = 4100 cfs				
USGS = 2900 cfs				
Portage Creek	3.85	834.22 (+1.68)	836.96	-
Slough 21, LRX-57	4.18	753.03 (+3.3)	754.70 (-0.8)	-
Slough 21, LRX-54	3.00 (-.06)	732.32 (+.1)	733.28	-
Gold Creek	-	681.94 (-.1)	-	-
Slough 11, Mouth	-	[1.26] (+.1)	[2.15] (-1.2)	-
Slough 9, Sherman	-	617.16	620.12	-
Slough 9, Mouth	2.07 (-.09)	[5.57] (-.2)	[5.78]	-
Slough 8, Head	5.30	-	-	3.6
Slough 8, LRX-28	-	552.39	-	-
Curry	3.06	522.46	524.77	-
McKenzie Creek	-	487.92	493.33	-
Lane Creek	2.87	[4.01]	[4.81]	3.6
LRX-11	-	[1.22]	[5.30]	-
LRX-9	-	379.32	383.93	-
LRX-3	3.68	340.97	342.40	-

TABLE 5.1 (Continued)

	Ice Thickness (ft)	Surface Elevation[1] (ft)	Top of Ice Elevation[1] (ft)	Velocity[3] ft/sec
April 29, 1983				
Gold Creek Discharge:				
Observed[2] = 4100 cfs				
USGS = 3100 cfs				
Portage Creek	2.81	833.04 (-1.18)	834.00 (-2.96)	-
Slough 21, LRX-57	3.85	753.10	754.52 (-.22)	2.4
Slough 21, LRX-54	2.91 (-.09)	732.32	733.25	-
Gold Creek	-	681.94	-	-
Slough 11, Mouth	1.25	[1.23]	[2.53]	-
Slough 9, Sherman	-	617.29 (+.1)	-	5.4
Slough 9, Mouth	2.02	[5.80] (+.2)	[5.64] (-.06)	-
Slough 8, Head	-	-	-	5.0
Slough 8, LRX-28	-	552.51 (+.13)	-	-
Curry	3.04	522.64 (+.18)	524.77	-
McKenzie Creek	-	488.05 (+.13)	-	-
Lane Creek	2.88	[4.18] (+.17)	[4.80]	-
LRX-9	-	380.63 (+1.31)	-	-
Talkeetna Airstrip	-	[0.55]	-	-
April 30, 1983				
Gold Creek Discharge:				
Observed[2] = 4325 cfs				
USGS = 3300 cfs				
Portage Creek	2.54 (-.30)	833.09	833.85 (-.20)	-
Slough 21, LRX-57	3.95 (+.10)	753.74 (+.64)	754.52	2.8
Slough 21, LRX-54	2.90	731.51 (-.81)	733.15 (-.10)	1.5
Gold Creek	-	682.05 (+.11)	-	3.6
Slough 9, Mouth	1.81 (-.20)	[5.82]	[5.54] (-.10)	-
Slough 8, Head	-	-	-	5.7
Lane Creek	2.92	[3.90] (-.28)	[4.83]	5.3
LRX-11	-	[1.81] (-.4)	-	-
LRX-3	3.61	343.43 (+2.46)	342.97 (+.57)	-

TABLE 5.1 (Continued)

	Ice Thickness (ft)	Surface Elevation[1] (ft)	Top of Ice Elevation[1] (ft)	Velocity[3] ft/sec
May 1, 1983				
Gold Creek Discharge:				
Observed[2] = 4700 cfs				
USGS = 3600 cfs				
Portage Creek	2.11	833.27 (+.2)	833.40 (+.4)	-
Slough 21, LRX-57	3.89	752.54 (-.6)	754.41 (-.1)	-
Slough 21, LRX-54	2.90	733.09 (+1.6)	733.35 (+.2)	-
Gold Creek	-	682.20 (+.15)	-	-
Slough 8, Head	-	-	-	6.5
Curry	2.93 (.1)	523.21 (+.6)	524.64 (-.1)	-
Lane Creek	3.01	[6.85] (+2.95)	[6.63] (+1.80)	
May 2, 1983				
Gold Creek Discharge:				
Observed[2] = 5750 cfs				
USGS = 3900 cfs				
Portage Creek	2.16	833.63 (+.36)	833.66 (+.26)	-
Slough 21, LRX-57	3.90	753.02 (+.48)	754.45	-
Slough 21, LRX-54	2.83	731.74 (-1.4)	733.09 (-.24)	-
Gold Creek	-	682.62 (+.42)	-	-
Slough 8, Head	-	-	-	8.1
Lane Creek	2.92	[6.37] (-.48)	[6.50] (-.13)	-
May 3, 1983				
Gold Creek Discharge:				
Observed[2] = 6180 cfs				
USGS = 4200 cfs				
Slough 21, LRX-54	2.81 (-.09)	731.91 (+.17)	733.08 (-.27)	-
Slough 11, Mouth	-	[4.88] (+3.65)	-	-
Slough 8, Head	-	-	-	9.6

TABLE 5.1 (Continued)

	Ice Thickness (ft)	Surface Elevation[1] (ft)	Top of Ice Elevation[1] (ft)	Velocity[3] ft/sec
<u>May 4, 1983</u>				
Gold Creek Discharge: Observed[2] = 6180 cfs USGS = 4500 cfs				
Gold Creek	-	682.78 (+.16)	-	-
Slough 8, Head	-	-	-	9.2
<u>May 5, 1983</u>				
Gold Creek Discharge: Observed[2] = no data USGS = 4900 cfs				
Slough 9, H9 berm	(breached)	606.51	-	-
Slough 9, Sherman	-	620.89 (+3.60)	-	-
<u>May 6, 1983</u>				
Gold Creek Discharge: Observed[2] = 10,920 cfs USGS = 5400 cfs				
Gold Creek	-	684.15 (+1.37)	-	-

TABLE 5.1 (Continued)

	Ice Thickness (ft)	Surface Elevation[1] (ft)	Top of Ice Elevation[1] (ft)	Velocity[3] ft/sec
May 10, 1983				
Gold Creek Discharge: Observed[2] = 14,350 cfs USGS = 5800 cfs				
Gold Creek	-	684.97 (+.82)	-	-

1. Values in brackets [ ] represent relative elevations based on an arbitrary datum from a temporary benchmark adjacent to the site. Values in parenthesis denote the increase (+) or decrease (-) since the previous measurement.

2. Observed discharges were extrapolated from the U.S.G.S. stage/discharge curve and are based on staff gage readings.

3. Velocities represent measurements obtained at one point on a section at a depth of 2 feet.

TABLE 5.2

SUSITNA RIVER AT SUSITNA STATION
BREAKUP OBSERVATIONS ON THE MAINSTEM

Date	Staff Gauge [1] (ft)	Mean Air Temperature [2] (°C)	Ice Thickness (ft)	Weather
April 1983				
1	-	4.7	-	-
2	-	4.7	-	-
3	-	0.8	3.3	Cloudy
4	6.18	2.8	3.3	Rain/Snow
5	6.23	3.1	3.3	Snow
6	6.30	3.1	3.3	Snow
7	6.33	3.3	3.3	Cloudy
8	6.33	3.1	3.3	Cloudy
9	6.35	3.6	3.3	Sunny
10	6.35	0.3	3.3	Sunny
11	6.35	0.0	3.3	Sunny
12	6.35	0.6	3.3	Snow
13	6.30	2.5	3.3	Snow
14	6.40	4.7	3.3	Rain
15	6.40	1.9	3.3	Rain
16	6.58	3.6	3.3	Snow
17	6.68	1.9	3.3	Rain
18	6.78	3.3	3.2	Snow
19	6.90	3.6	3.2	Cloudy
20	7.00	3.6	3.1	Cloudy
21	7.10	4.2	2.8	Sunny
22	7.33	6.4	2.6	Cloudy
23	7.63	6.9	2.6	Rain
24	7.95	6.9	2.4	Sunny
25	8.68	10.0	2.3	Sunny
26	9.43	7.5	2.3	Sunny
27	11.10	6.1	2.2	Sunny
28	11.45	3.6	2.1	Cloudy
29	11.00	5.6	2.1	Cloudy
30	11.45	3.6	1.9	Sunny
May 1983				
1	-	6.4	-	Sunny
2	-	5.0	Ice began moving	Cloudy
3	-	6.9	Ice flowing	Cloudy
4	-	5.6	Ice flowing	Cloudy
5	-	5.8	Ice flowing	Cloudy
6	-	6.7	Open	Sunny
7	-	8.3	Open	Sunny
8	-	9.4	Open	Sunny
9	-	9.2	Open	Sunny
10	-	9.2	Open	Cloudy
11	-	11.1	Open	Cloudy
12	-	12.5	Open	Cloudy

1. Relative elevation based on an arbitrary datum.
2. Average of the maximum and minimum temperatures.

/cc1

TABLE 5.3

SUSITNA RIVER AT THE DESHKA RIVER CONFLUENCE BREAKUP OBSERVATIONS ON THE MAINSTEM

Date	Staff Gauge [1] (ft)	Mean Air Temperature [2] (°C)	Ice Thickness (ft)	Snow Depth (ft)	Weather
April 1983					
1	0.00	1.4	3.7	-	Sunny
2	0.00	1.7	-	-	Sunny
3	0.00	1.1	-	-	Sunny
4	0.00	3.3	-	-	Snow
5	0.00	1.7	-	-	Rain
6	0.00	1.9	-	-	Fog
7	0.00	1.1	-	-	Sunny
8	0.00	1.7	-	-	Cloudy
9	0.00	2.2	-	-	Cloudy
10	0.00	-1.1	-	0.10	Sunny
11	0.00	-5.8	-	0.20	Cloudy
12	0.10	-0.6	-	1.20	Snow
13	0.10	1.9	-	0.80	Cloudy
14	0.20	3.1	-	-	-
15	0.40	3.3	-	-	-
16	0.50	4.2	-	-	-
17	0.50	1.7	-	1.0	Snow
18	0.60	2.8	-	-	Cloudy
19	0.70	4.2	-	-	Cloudy
20	1.00	4.2	-	-	Cloudy
21	1.00	4.7	-	-	Sunny
22	1.20	6.7	-	-	Rain
23	2.00	5.8	-	-	-
24	2.40	7.2	-	-	Sunny
25	3.40	5.8	-	-	Sunny
26	3.40	6.7	-	-	Sunny
27	3.80	6.4	-	-	Sunny
28	3.80	3.6	-	-	Cloudy
29	3.80	6.1	-	-	Rain
30	4.10	6.4	-	-	-
May 1983					
1	4.30	6.7	-	-	-
2	-	8.3	-	-	-
3	-	7.5	-	-	-
4	-	7.8	Ice began moving	-	-
5	-	6.9	Ice flowing	-	-
6	1.00	6.1	Ice flowing	-	-
7	1.20	7.8	Ice flowing	-	-
8	1.20	9.2	Ice flowing	-	-
9	1.20	9.7	Ice flowing	-	-
10	1.00	8.9	Ice flowing	-	-
11	1.00	8.6	Open	-	-
12	1.10	10.3	Open	-	-
13	1.90	10.6	Open	-	-
14	1.50	10.3	Open	-	-
15	1.50	10.6	Open	-	-

Relative elevation based on an arbitrary datum.
Average of the daily maximum and minimum temperatures.

s5/cc2

TABLE 5.4

SUSITNA RIVER AT GOLD CREEK
BREAKUP OBSERVATIONS ON THE MAINSTEM

Date	Staff Gauge (ft) [1]	Discharge (cfs) [2]	Mean Air Temperature (°C) [3]	Open Channel Width (ft) [4]	Weather
April 1983					
17	-	1700	2.8	16	Snowing
18	-	1800	5.6	16	Partly Sunny
19	-	1800	6.9	20	Sunny
20	-	1900	5.8	25	Sunny
21	-	2000	8.6	40	Sunny
22	-	2000	8.3	40	Rain
23	2.80	2100	9.7	40	Partly Cloudy
24	2.90	2300	12.5	40	Sunny
25	-	2400	8.9	40	Sunny
26	-	2500	8.6	40	Sunny
27	2.57	2700	9.2	50	Sunny
28	2.49	2900	7.5	80	Cloudy
29	2.49	3100	5.0	150	Rain
30	2.65	3300	-	200	Sunny
May 1983					
1	2.75	3600	8.1	Open	Sunny
2	3.17	3900	8.3	Open	Sunny
3	3.30	4200	7.2	Open	Rain
4	3.33	4500	8.6	Open	Sunny
5	-	4900	7.2	Open	Sunny
6	4.70	5400	-	Open	Sunny
7	5.52	5800	-	Open	Sunny
8	-	6400	-	Open	Sunny
9	-	7200	-	Open	Sunny
10	-	8000	-	Open	Partly Cloudy
11	-	9000	-	Open	Sunny

1. Relative elevations based on an arbitrary datum.

2. Provisional data subject to revision by the U.S. Geological Survey, Water Resources Division, Anchorage, AK.

3. Average of the daily maximum and minimum temperatures.

4. Visual estimation based on one daily observation.

WATER SURFACE PROFILES ALONG 1600 FEET OF RIVER BANK ADJACENT TO SLOUGH 21 BEFORE AND DURING ICE JAM

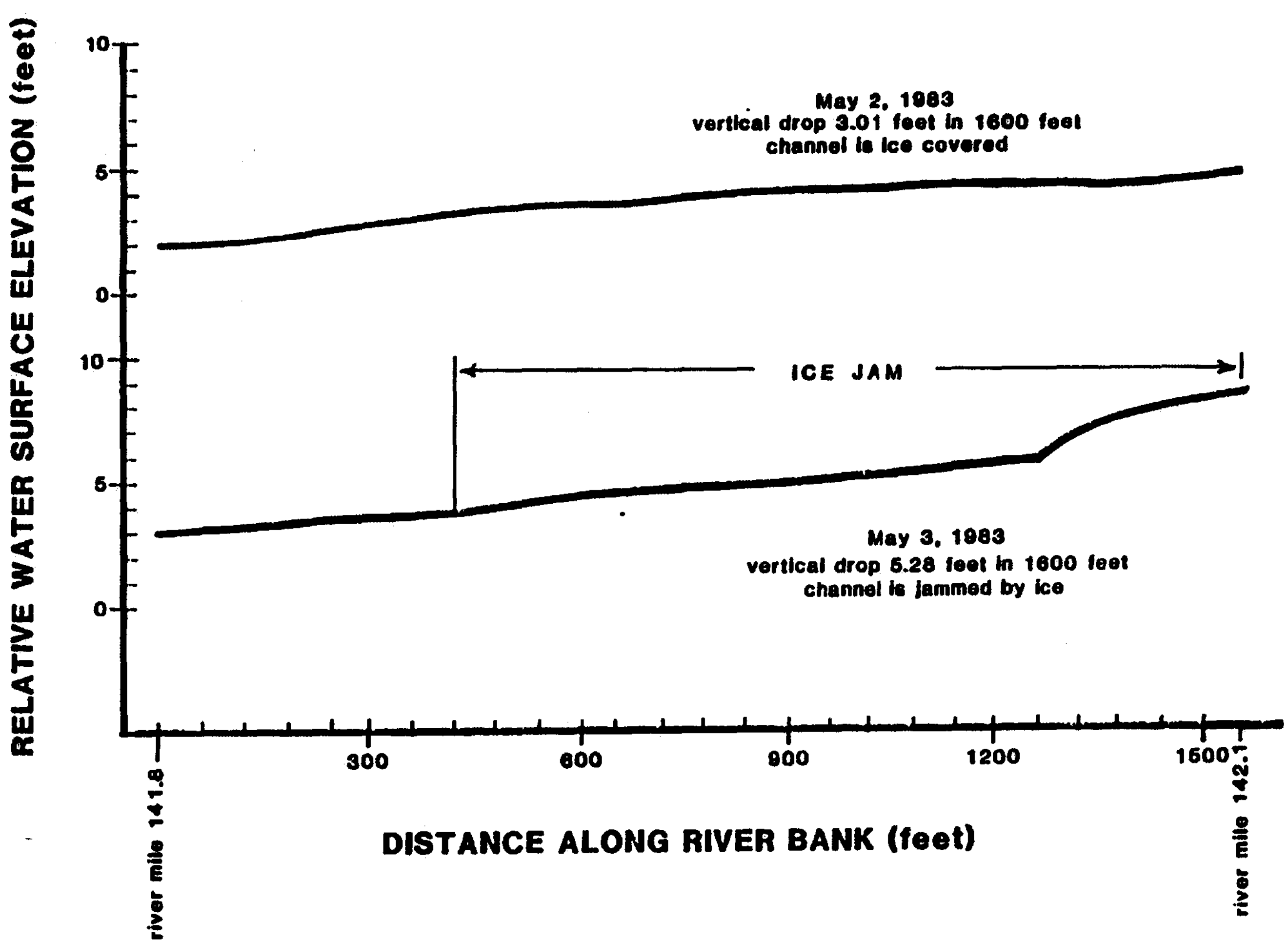

Figure 6.1

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SUSITNA JOINT VENTURE

s8/w11

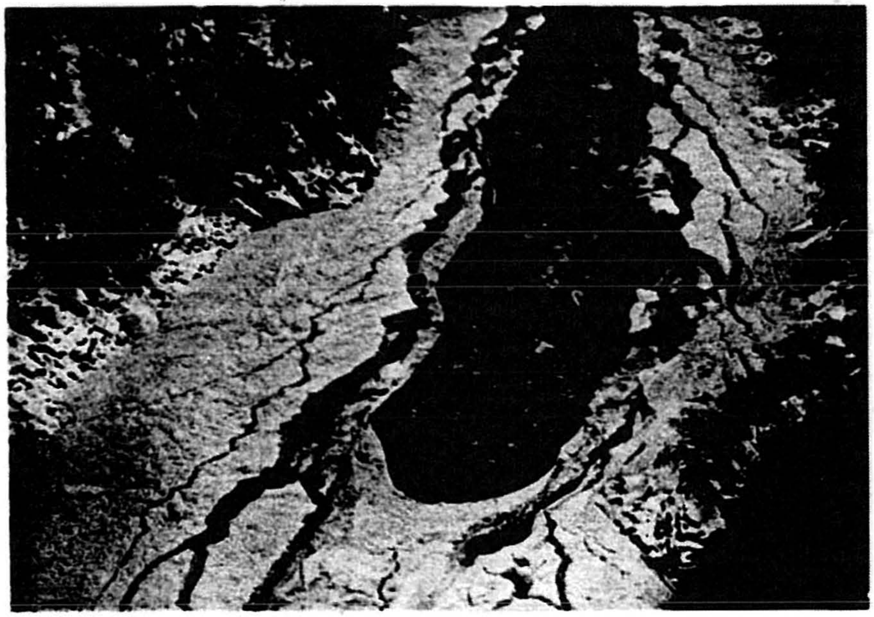

PHOTO 5.1

Ice cover in Devil Canyon at river mile 151 on October 20, 1982. The ice thickness along the shore is about 4 feet and will eventually thicken to over 15 feet. Flow is from lower left to upper right.

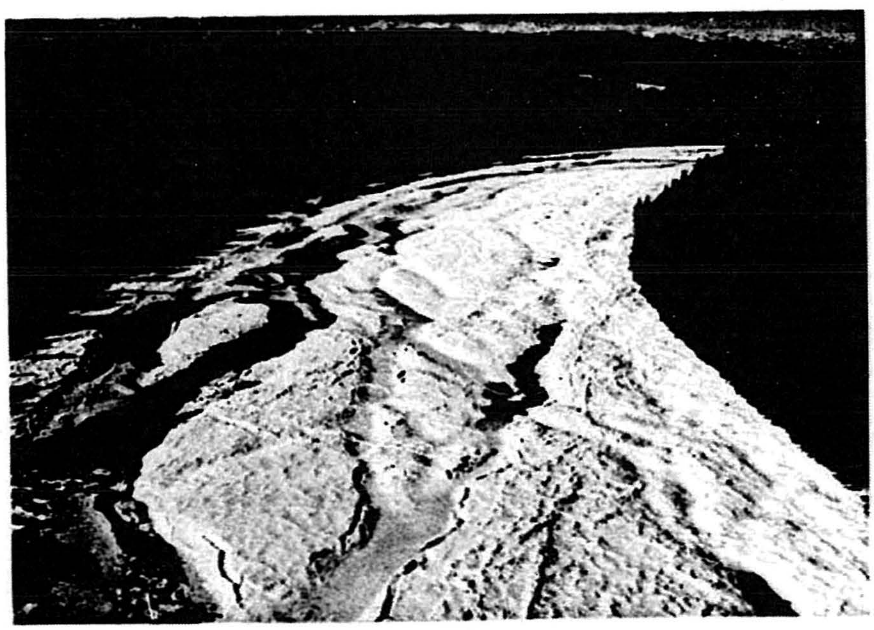

PHOTO 5.2

View looking upstream at river mile 107 on April 7, 1983. Water filled depressions in the ice cover, enlargement of open leads, and accumulations of ice fragments on the downstream end of leads are evident and are usually the first indications of breakup.

s8/w12

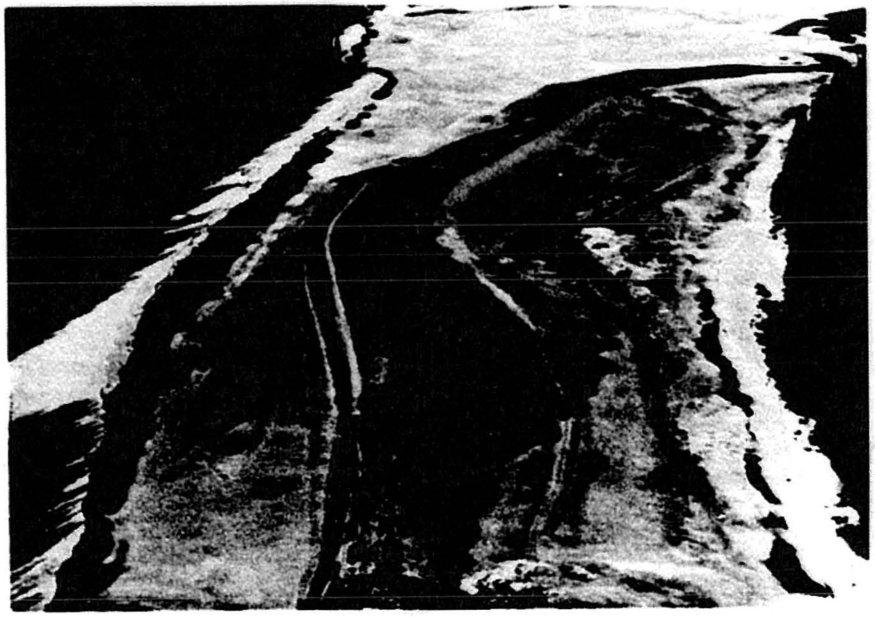

PHOTO 5.3
View looking downstream on the upper Susitna River near the confluence of Fog Creek. By April 28, 1983 much of the snow cover had melted, exposing the bare ice to direct incident solar radiation. The water level had increased sufficiently to overflow on the ice cover and widen the channel.

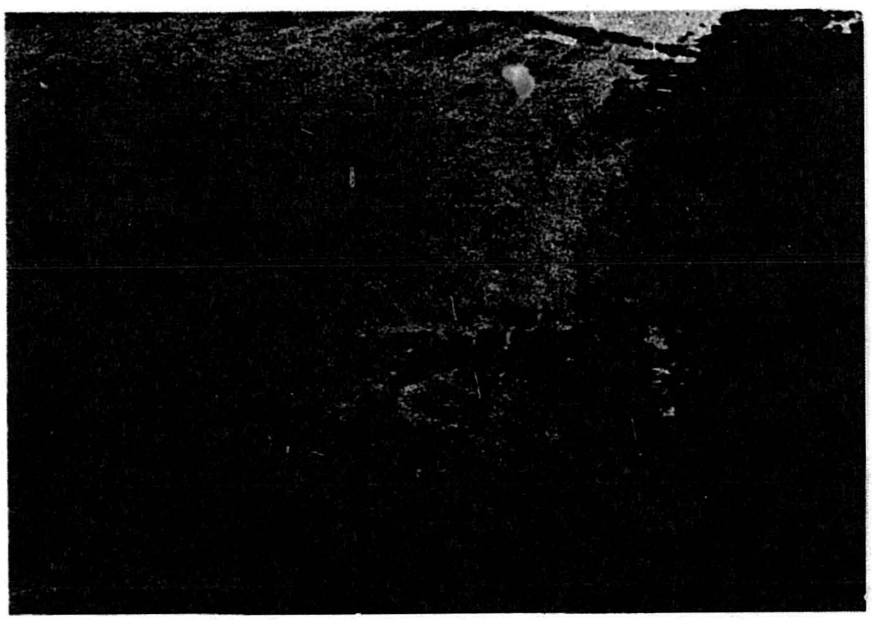

PHOTO 5.4
This moose fell through and became entrapped in the slush ice during freeze-up.

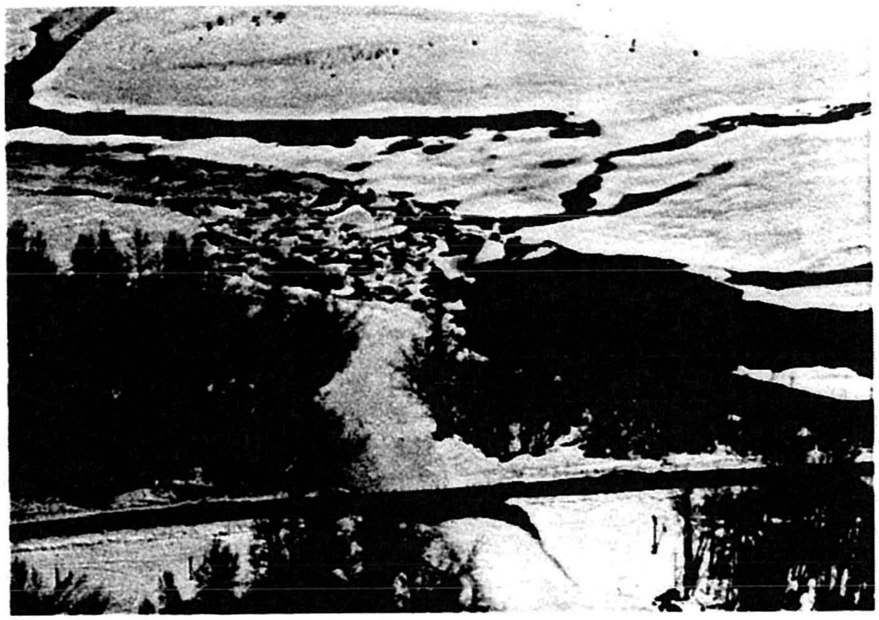

PHOTO 5.6
The confluence of Deadhorse Creek (at Curry) on April 28, 1983. Flow on the mainstem is from right to left. Open lead on the right is enlarging and fragments of ice are accumulating against the solid ice cover at the downstream end.

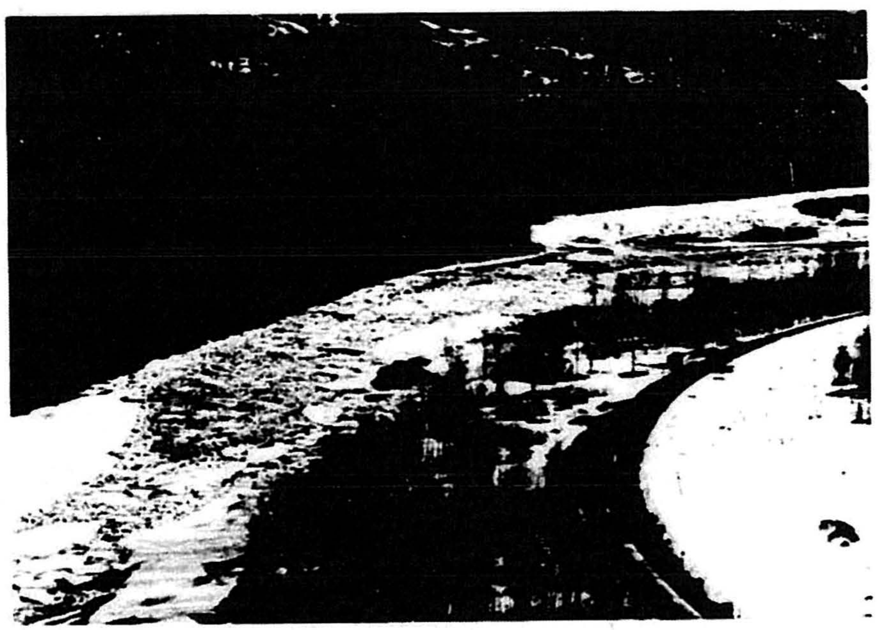

PHOTO 5.5
This photo shows a large ice jam at Curry on May 6, 1983. This jam was gradually progressing downstream as the solid ice cover holding back the debris slowly disintegrated.

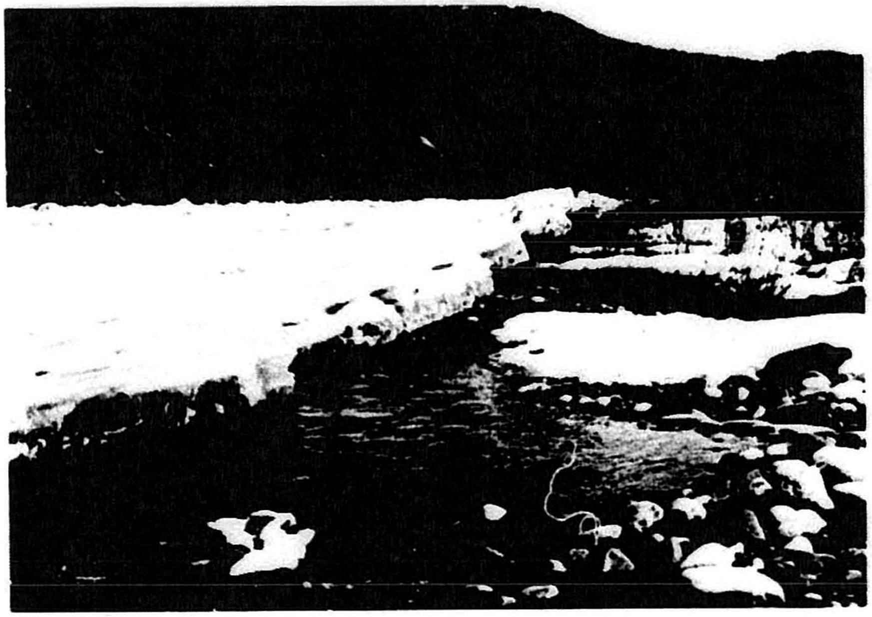

PHOTO 5.7

When this ice jam adjacent to Slough 21 consolidated on May 4, 1983 it created a surge wave that snapped loose the shore ice and heaved blocks onto a gravel island. The view is looking upstream along the south bank. This ice is about 4 feet thick and the area affected by the surge extended several hundred feet.

PHOTO 5.8

This is a close-up view of the ice blocks shoved over the river bank at Slough 21 on May 5, 1983. Note the debris scoured by the ice.

s8/w15

PHOTO 5.9
Gravel and cobble size particles being rafted downstream on ice floes near Slough 21 on May 5, 1983.

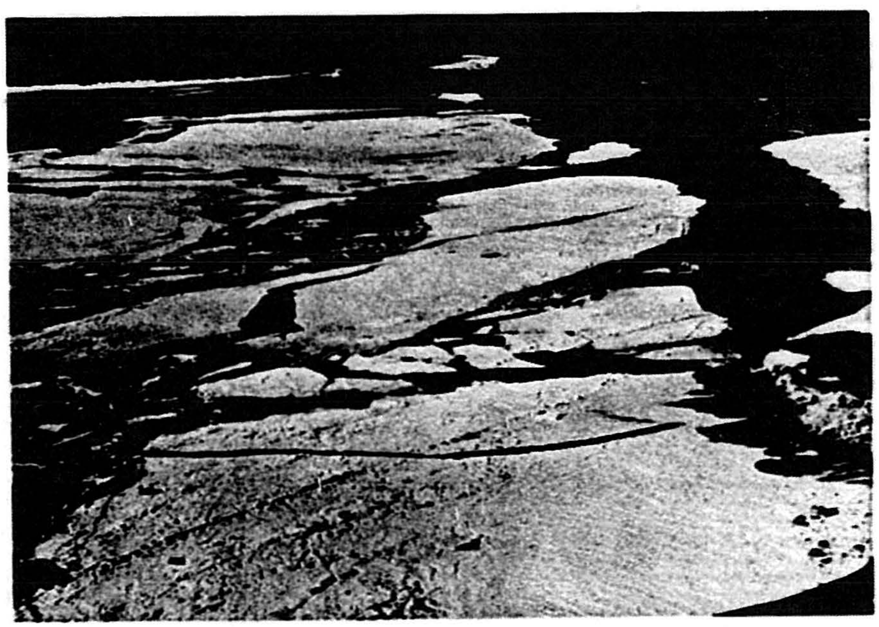

PHOTO 5.10
This shows the key of an ice jam adjacent to Slough 11 releasing. This jam was about .7 miles long on May 6, 1983 . The pressure exerted on the shore-fast ice by this accumulation snapped loose these massive ice sheets.

s8/w16

PHOTO 5.11
An aerial view of the ice jam near Sherman at river mile 131.5 on May 6, 1983. The flow is from left to right. The original jam had released but the large ice sheets wedged and created this new, and very stable, ice jam that lasted for 2 days.

PHOTO 5.12
This is a close-up view of the ice sheet that wedged near Sherman. Massive blocks of ice had fragmented and formed ridges along the shear surfaces.

s8/w17

PHOTO 5.13
The ice sheets holding back the ice jam at Sherman gradually decayed and weakened. They are shown here on May 8, buckled and fractured just before they released. Flow is from right to left.

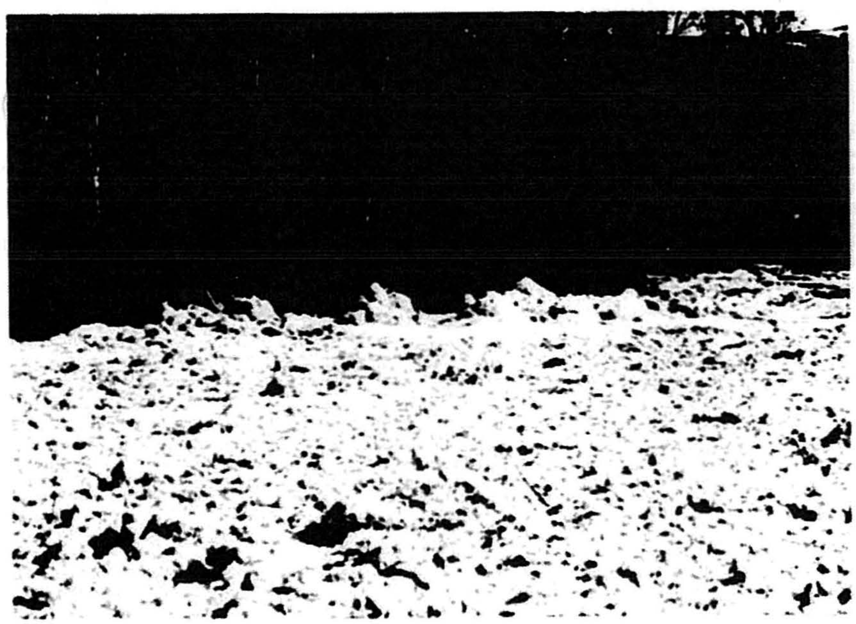

PHOTO 5.14
The ice jam at Sherman accumulated over 1 mile of debris. The subsequent staging and pressure within the ice pack shoved floes onto the forested islands. This often knocked trees down and caused ice scouring.

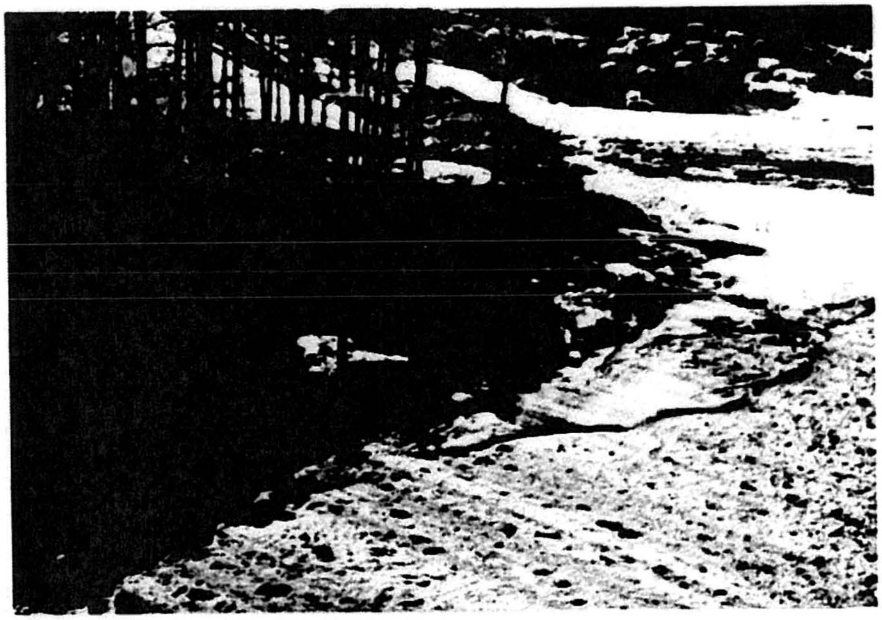

PHOTO 5.15
The mainstem channel at Sherman was choked with ice and debris which redirected flow into a side channel adjacent to the mainstem. This island was flooded after the jam consolidated and raised the water level about 2 feet on May 8, 1983.

PHOTO 5.16
This photo shows the effects of an ice jam near the Susitna confluence at river mile 98 that caused flooding on the adjacent terrace plain, sending ice floes deep into the forest.

s8/w19

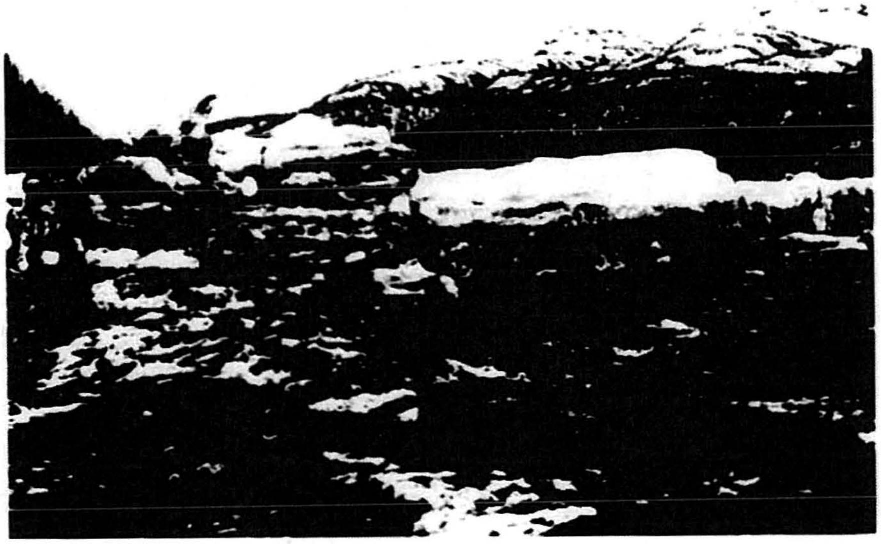

PHOTO 5.17

After the ice jam released at Curry on May 7, these ice blocks remained stranded on the gravel bar below Deadhorse Creek. Some are over 6 feet thick. The large block on the right rests on an extensive layer of solid ice about 0.5 foot thick.

PHOTO 5.18

Poorly graded, angular particles shoved up onto an ice sheet at Curry during the ice jam release on May 5, 1983.

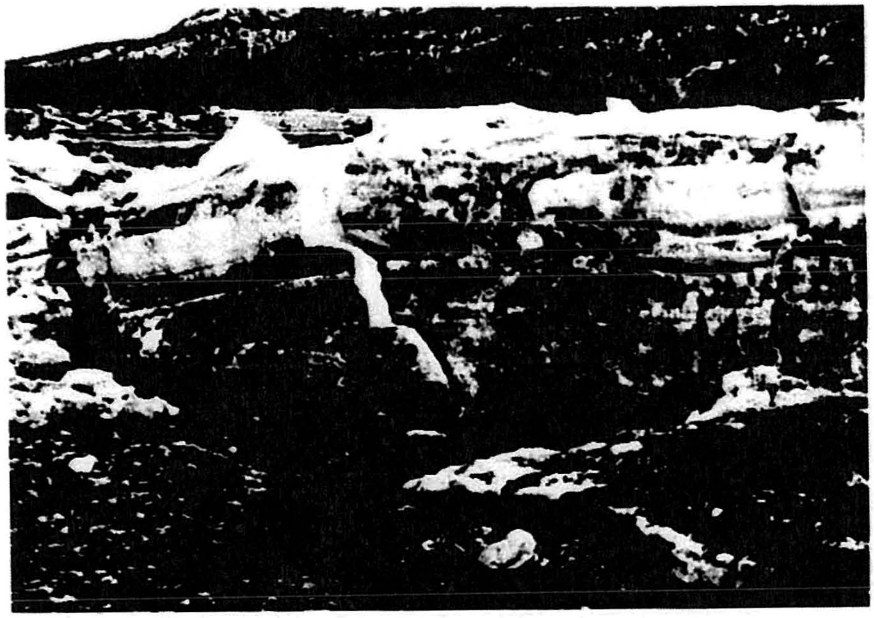

PHOTO 5.19
Massive blocks of consolidated slush ice with clear ice lenses. The ice cover, consisting of packed slush ice, is inherently weak and will fracture easily if not supported by water or surrounding ice.

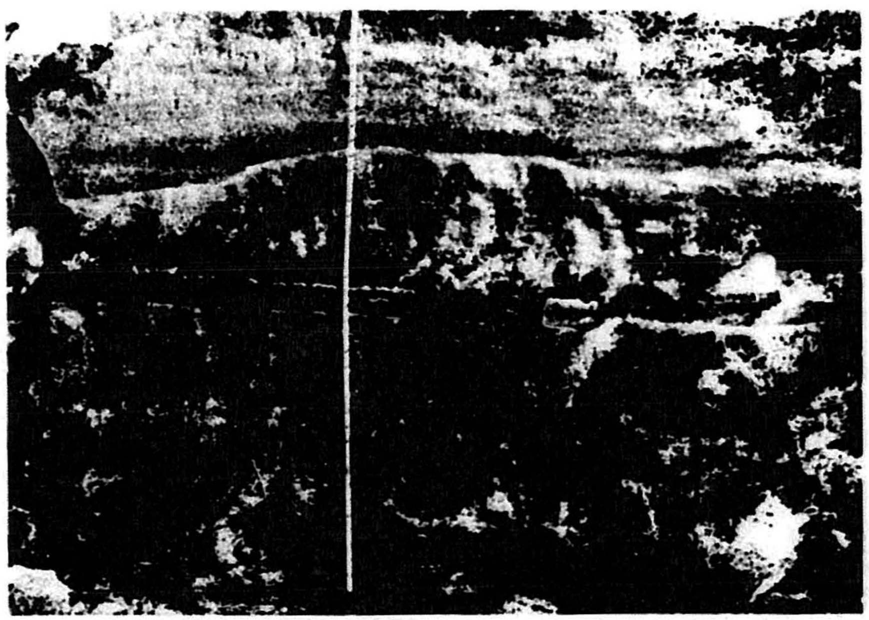

PHOTO 5.20
Stratigraphy within an ice cover fragment showing alternate layers of packed slush ice and rigid ice lenses. Tape is incremented in tenths of a foot.

s8/w21

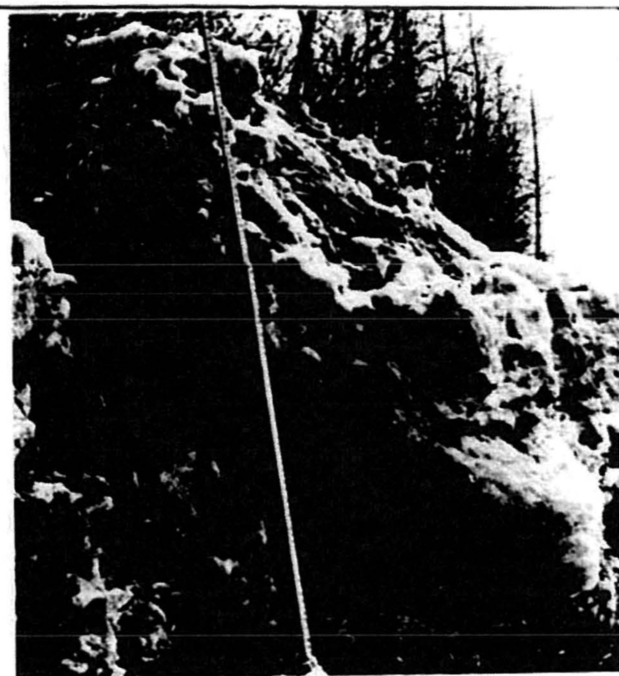

PHOTO 5.21
Large ice fragment stranded on a bank after the ice jam at river mile 107 released. The rod is 13 feet high.

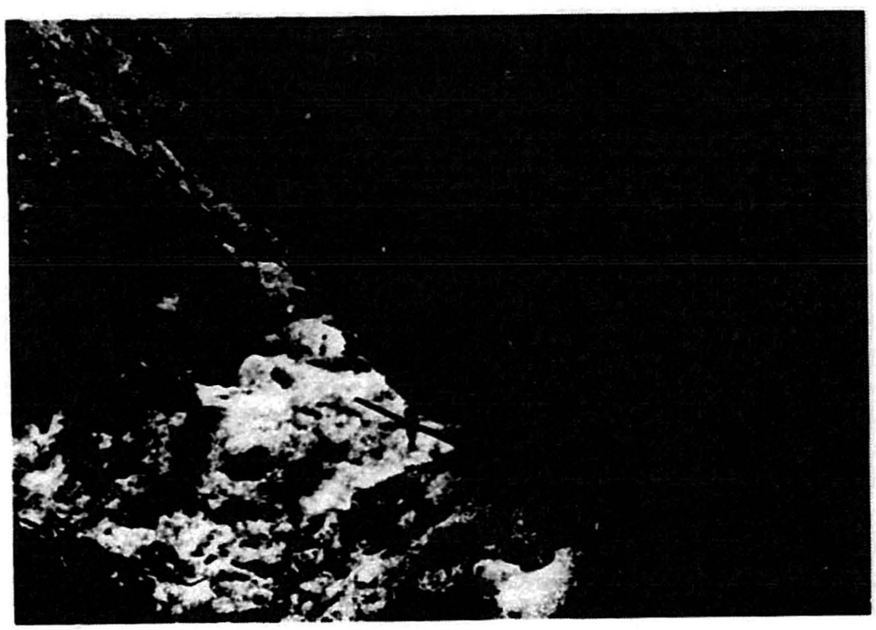

PHOTO 5.22
The characteristic rippling on the underside of an ice cover. This erosion feature is caused by the action of waves in turbulent reaches.

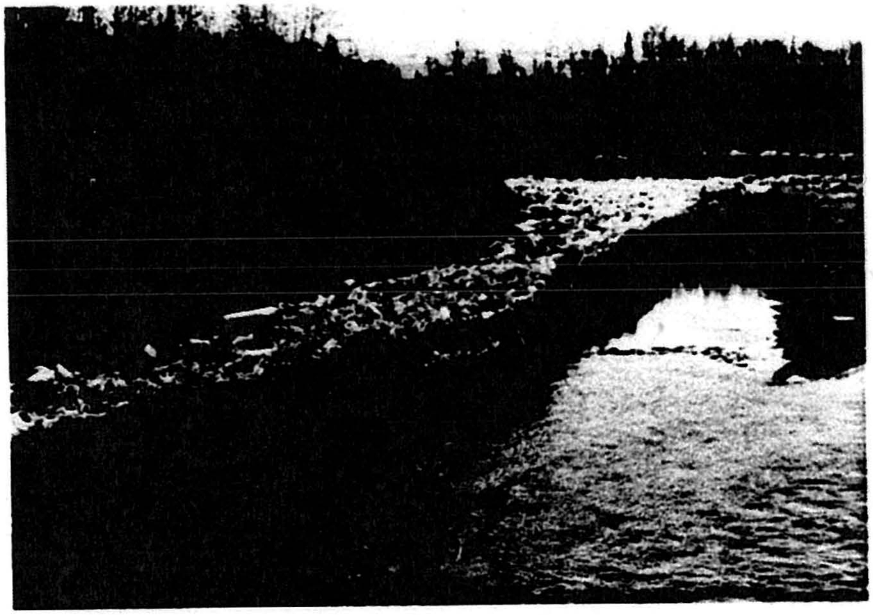

PHOTO 5.23

Ice debris piled onto the river bank at river mile 101.5. The shear wall is approximately 14 feet high. The water level attained during the ice jam is indicated by a line separating the dark layer, with a high sediment concentration, from a lighter and thinner layer on the surface.

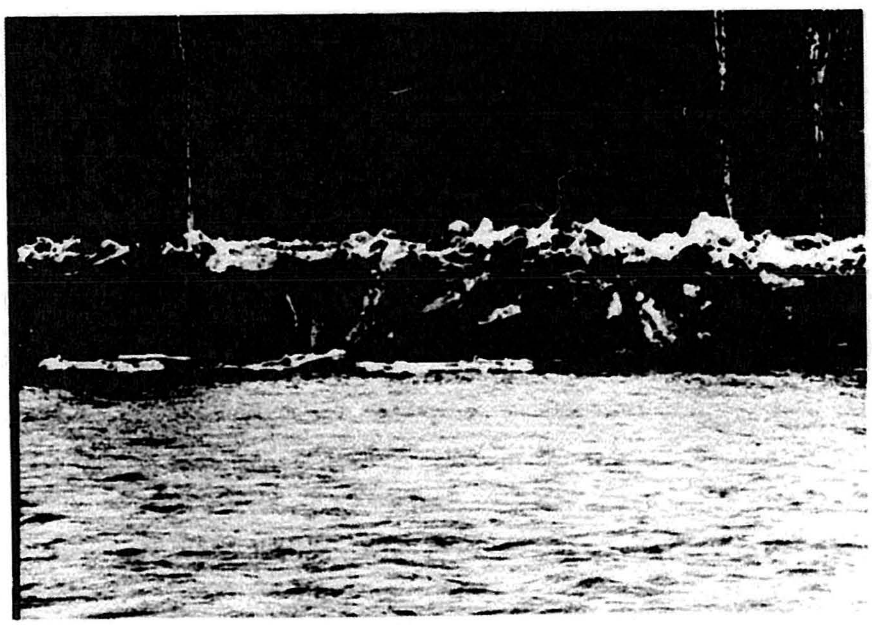

PHOTO 5.24

View of the shear wall along accumulated ice debris stranded on the right bank near river mile 110. Flow is from right to left. This photograph was taken on May 10, 1983 about 8 hours after the ice jam released. The wall is about 16 feet high.

PHOTO 5.25
After the ice jam released near Chase, the ice severely scoured the river banks and carried away large trees.

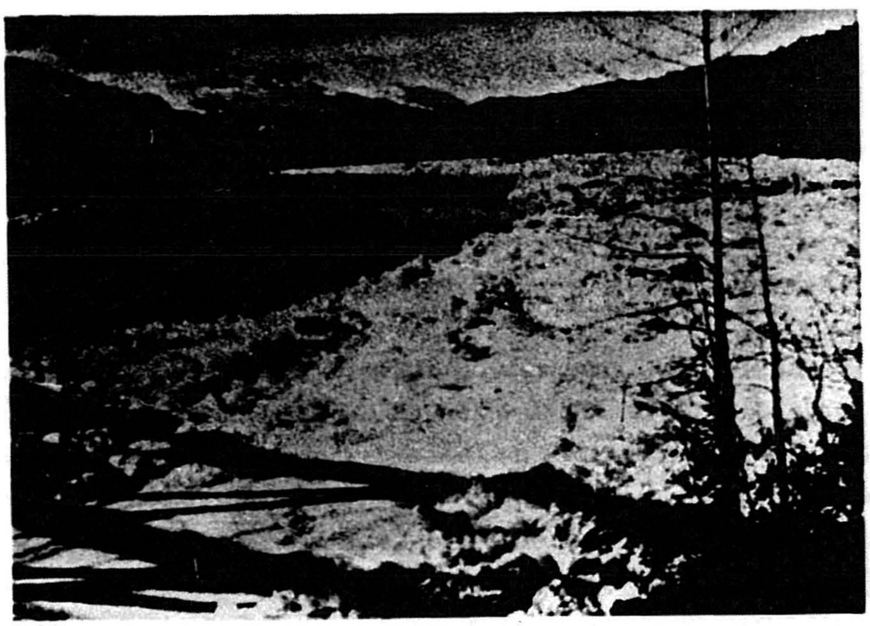

PHOTO 5.26
This photo was taken on May 7, 1976 from the Gold Creek Bridge, looking downstream towards Slough 11. The mainstem is completely ice choked and much flow has been diverted to the left into Slough II.

6.0 SEDIMENT TRANSPORT

The transportation of sediments decreases substantially between freeze-up and breakup primarily because of the elimination of glacial sediment input. The glaciers contribute the majority of the suspended sediment by volume to the Susitna. Other factors that significantly influence the sediment regime are turbulence, velocity, and discharge, all of which are greatly reduced during the winter. The advent of frazil ice in October, however, greatly increases the complexity of sediment transport by providing a variety of processes by which particles, both in suspension and saltation, can be moved. Ice nucleation, suspended sediment filtration, and entrainment of larger particles in anchor ice are some of the processes described in this section. The dramatic nature of breakup often introduces sediment to the flow by re-entraining particles that had settled to the bottom. This ice event is characteristically accompanied by ice scouring and erosion during extreme stages. Ice jam induced flooding commonly flushes sediments from side channels and sloughs. Ice blocks are heaved onto river banks or scraped against unconsolidated depositional sediments, removing soils which may become entrained in the turbulent flow and carried downstream.

Laboratory investigations have determined that ice readily nucleates around supercooled particles. These particles may be in the form of organic detritus, soils, or even water droplets (Osterkamp, 1978). The Susitna River prior to freeze-up abounds in clay size sediment particles which may form the nucleus of frazil ice crystals. The first occurrence of frazil is generally also marked by a reduction in turbidity. Visual observations seem to indicate that the decrease in turbidity is proportional to the increase in frazil ice discharge. The Susitna has often been observed to clear up overnight during heavy slush flows. It is not certain whether this occurs because of the nucleation process or by filtration.

As described in previous sections, frazil ice crystals tend to flocculate into clusters and adhere together as well as to other objects. When frazil floccules agglomerate they form loosely packed slush (Newbury, 1978). Water is able to pass through this slush but suspended sediments are filtered out. Sediment particles are therefore entrained in the accumulating ice pack. Ice shavings from bore holes drilled through the ice often contain silt-size particles of sediment. Early flows of slush ice accumulate on the lower river below Susitna Station and progressively advance upstream. These early slush floes possibly filter high sediment concentrations in October and retain them in suspension all winter.

When frazil ice collects on rocks lying on the channel bottom, it is referred to as anchor ice (Michel, 1971). Anchor ice is usually a temporary feature, commonly forming at night when air temperatures are coldest, and releasing during the day. Like slush ice, anchor ice is porous and often has a dark brown color from high sediment concentrations. These sediment particles were either once suspended and subsequently filtered out of the water or else were transported by saltation until they adhered on contact with the frazil. When anchor ice breaks loose from the bottom, it generally lacks the structural competence to float any particles larger than gravel-size. Clusters of released anchor ice, suspended in the ice pack and clear border ice, have been observed near Gold Creek. Frazil slush is therefore an effective medium for sediment transport during freeze-up whether the process is nucleation, filtration or entrapment.

An ice cover advancing upstream can cause a local rise in water levels, often flooding previously dry side channels and sloughs. Substantial volumes of slush ice may accompany this flooding. On December 15, 1982, Sloughs 8 and 8A were flooded when the ice pack increased in thickness on the mainstem immediately adjacent to the slough entrance. These sloughs received a disproportionate volume of slush ice relative to water volume since the water breaching the berm constituted only the very top layer of mainstem flow. The majority of slush ice floats near the water surface despite only minimal buoyancy. The flow spilling over the slough berms therefore carried a high concentration of ice. This slush ice and entrained sediment rapidly accumulated into an ice cover that progressed up the entire length of Slough 8A.

Side channels and sloughs that were breached during freeze-up and filled with slush ice are not necessarily flooded during breakup. If these sloughs are not inundated then the ice cover begins to deteriorate in place. The entrained sediment consolidates in a layer on the ice surface and effectively reduces the albedo, further increasing the melt rate. What finally remains is a layer of fine silt up to ½ inch thick covering the channel bottom and shoreline.

If berms are breached during breakup, then ice fragments from the main channel are washed into the slough and usually become stranded when flows dissipate. These ice floes then simply melt in situ, depositing their sediment load in the side channel. This occurred in May 1983 when the "A5" access channel to Slough 21 flooded during a major mainstem ice jam.

Shore-fast ice along the perimeter of an ice jam is usually not floating. When debris accumulating behind a jam consolidates, the resulting surge wave may provide the critical lifting force to suddently shift the border ice. This occurred near Slough 21 on May 4, 1983. Tons of ice were shoved onto a gravel island entraining particles up to boulder-size and producing ridges of cobbles, gravels and organics. By this process of laterally shoving substrate material, ice can build up or destroy considerable berms and decrease the size of gravel bars near ice jam locations. When the lateral pressure exerted by ice is complicated by simultaneous downstream movement such as during an ice jam release, the effects on the river banks can be devastating. Many cubic feet of bank material was scoured away in minutes when massive jams released near Slough 21, Sherman, and Chase in May 1983.

An interesting phenomenon observed during breakup was the effective filtering capability of ice jams and individual ice blocks. Sediment-ladened water flows through the many channels and interstices between the fragments in an ice jam. These interstices are usually filled with porous slush which removes suspended sediments from the water. Ice jams can concentrate sediment in this manner and often become very dark in color.

As discussed, Susitna River ice generally consists of alternating layers of rigid, impermeable clear ice and porous, loosely packed, rounded crystals of metamorphosed frazil ice. Water can percolate through the permeable layers which strain out suspended sediment particles. This sediment becomes concentrated when the ice melts and is either re-entrained into suspension or deposited on the river bank if the ice floes were stranded.

7.0 ENVIRONMENTAL EFFECTS

This section briefly discusses the significant aspects of river ice relative to channel morphology, aquatic and terrestrial habitats, and vegetation. Ice obstructions in the thalweg result in hydraulic scouring, flow diversions and flooding of isolated sloughs. Ice floes shifting during freeze-up and the transportation of ice blocks by breakup floods can remove bank and bed material and create vegetation trim lines. On the upper Susitna River between the Chulitna confluence and Devil Canyon, there are reaches especially prone to annual ice damage while the river below Talkeetna rarely experiences dramatic ice events. This can be attributed to contrasting river morphology, the upper river is narrow and steep and the lower river is generally broad and shallow.

7.1 Susitna River Below the Chulitna River Confluence

This section of river is characterized by a broad, multichannel configuration with distances between vegetated banks often exceeding 1 mile. The thalweg is represented by a relatively deep meandering channel that usually occupies less than 20 percent of the total bank to bank width. At low winter flows, therefore, the thalweg is bordered by an expanse of sand and gravel.

The variation in average monthly discharges are extreme for total flows below Talkeetna, normally ranging from about 3,000 cfs in March at Sunshine to over 60,000 cfs during the summer, with peak flows being much higher. The stage fluctuations corresponding to these discharges are usually not severe because the broad channel has a high flow capacity. Ice cover progression frequently increases the stage about 1-2 feet above normal October water levels. No significant flooding takes place, for even at these stages the flow usually remains well within the channel boundaries. The lower river ice cover is therefore often confined to the thalweg and surface profiles do not approach the vegetation trim line along the banks. The existing trim lines are indicators of peak summer flows rather than ice scour.

Tributaries to the lower river seldom enter the mainstem directly. Willow, Kashwitna, and Sheep Creeks first flow into side channels and are rarely affected by stage increases due to ice cover progression. Montana Creek however, feeds the thalweg channel and on October 28, 1982 the confluence was flooded by about 1 foot of slush ice which subsequently froze. This ice cover had little effect on the tributary flow regime since the streamflow quickly opened a channel through the slush. Rabideux Slough was flooded with saturated slush on October 29. The ice cover had reached the Parks Highway Bridge and caused water levels to rise about 2 feet. This was sufficient to overtop the berms normally isolating the slough. The staged water had expanded out of the thalweg channel and reached both banks at the bridge. Portions of Birch Creek Slough, Sunshine Slough, Rabideux Slough and Goose Creek Slough, were also inundated by slush and formed an ice cover. Groundwater seeping into these channels, however, prevented a continuous cover from remaining all winter.

Breakup ice jams have occurred near the confluence of Montana Creek and also at river miles 85.5 and 89. Extensive areas of gravel and sand were flooded in 1983 despite minimal stage increases. The majority of the inundated side channels were affected only by water and no erosion or scouring by ice blocks was observed.

This section below the confluence regularly experiences extensive flooding during summer storms. These seem to have significantly more effect on the riverine environment than processes associated with ice cover formation.

7.2 Susitna River Above the Chulitna River Confluence

The effects of river ice between the Chulitna confluence at RM 98 and Portage Creek at RM 149 are evident by the ice scars on trees, the scoured sloughs and side channels, and the drumlin shaped islands. Under normal winter conditions, the ice is actively affecting channel morphology, vegetation, terrestrial and aquatic habitats, and groundwater levels. This reach could be severely impacted by ice regime modifications induced by increased winter discharges from hydroelectric dam projects at Devil Canyon and Watana.

Slush ice can obstruct the flow in the mainstem and divert water and ice into side channels. This has been observed annually on the river reach between Whiskers Creek and the Chulitna confluence. The shallow, multichannel area between Slough 8 and 9 also frequently has flows redirected by slush ice obstructions. These flow diversions during freeze-up however, do not cause much erosion or vegetation damage.

Ice obstructions during breakup in the mainstem can divert large volumes of ice into side channels. If the subsequent erosion is severe and the side channel bottom is lowered, then the mainstem flow could permanently shift. This shift in flow from one bank to the other will tend to enlarge the river boundaries. This process is evident in an early stage at RM 130.6 and more advanced at RM 112.7.

Scour holes occur where an ice cover or ice jam has created a conduit, directing flow against the bottom. Velocities through these confined channels cause great hydraulic forces which can scour the bed material to considerable depths. Scour holes may therefore be good indicators of frequently recurring ice jam locations. A typical cross section at a scour hole consists of a shallow gravel bar on one bank tapering to a deep and narrow thalweg along a vertical outcrop.

Depth soundings at these cliffs sometimes indicate holes in excess of 25 feet (R&M, 1981a). Cross section surveys have identified scour holes at the following locations: RM 135.9 along the right bank, RM 131.4 along the left bank, and RM 128.5, RM 126.5, and RM 120.5 along the right bank (See Appendix B). These sites correspond to frequently recurring ice jam locations.

Rapid and extreme staging at major ice jams occurs during breakup. Water levels generally continue to rise until either the jam releases or the water leaves the channel, inundating sloughs and flooding islands. On May 5, 1983 near Sherman at RM 133, a jam caused extensive flooding that flowed over the forested islands adjacent to the mainstem. These flood stages persisted for over 48 hours, leaving a deposit of sediment on the forest floor. The long-term effects of these short duration floods are not known, however, burrowing, nesting, and spawning habitats must certainly be impacted.

The frequency of major ice jam events is often indicated by the age or condition of vegetation on the upstream end of islands in the mainstem. Islands that are annually subjected to large jams usually show a stand of ice scarred mature trees ending abruptly at a steep and often undercut bank. A stand of young trees occupying the upstream end of islands probably represents second generation growth after a major ice jam event destroyed the original vegetation. Denuded gravel bars may be advanced ice scour features. Vegetation is prevented from re-establishing by ice jams that completely override these islands.

Ice jams do not consistently occur every year at the same locations. Their magnitude and conditions controlling formation are usually unpredictable. Areas where jams occur frequently are evident by numerous side channels and sloughs. Major ice events probably formed the sloughs when ice floes surmounted the river banks. The

esp b/tw Curry & Gold Creek (... p. 104) size and configuration of existing sloughs is dependent on the frequency of ice jamming in the adjacent mainstem. Susitna River sloughs are usually flooded at high summer discharges when berms normally isolating these side channels are breached. These berms usually consist of unconsolidated particles larger than the hydraulic competence of the overtopping flow and therefore summer erosion is often limited. Ice floes, however, weighing many hundred pounds can easily move the bed material, substantially lowering the entrance berms and the slough bottom. This was observed at Slough 21 in May, 1983. A surge wave overtopped a shallow gravel bar that isolated a side channel. The surge also created enough lifting force to shift large ice floes. These floes barely floated but were carried into the side channel by the onrush of water, dragging against the bottom for several hundred feet, dislodging cobbles, and scouring troughs in the bed material. This same process will also enlarge the sloughs. When staging is extreme in the mainstem and a large volume of water spills over the berms, then ice floes drift into the side channel scouring the banks and moving bed material, thus expanding the slough perimeter. This scouring action by ice can therefore drastically alter the aquatic habitat. Summer flows that periodically breach the sloughs are usually of low velocities and generally do little to modify the channel, however, they may cause transport of silt and sand within the channel.

By examination of the valley geomorphology, river morphology, and ice processes, it seems that islands, gravel bars, river banks, and the thalweg are features more controlled by ice scouring and overriding than by annual summer floods. These floods often approach the vegetation trim line along the bank, but many denuded gravel bars remain exposed even during the annual flood.

Based on observations from 1981 to 1983, it seems that ice jams have significant effects on riverine habitats. As previously described, these effects can best be studied from Slough 21 downstream to

Chulitna confluence. A major jam has formed annually for the last 3 years from the Chulitna confluence (RM 90) to Chase (RM 108). The jam height of more than 15 feet was more than sufficient to override all the gravel bars in the area and severely scour forested islands. When this jam broke and the ice moved downstream along both sides of many mainstem islands, many feet of unconsolidated bank material were removed. The islands between RM 107 and RM 100 (see Appendix B) show the characteristic drumlin shape of mainstem river ice erosion. The morphologic evidence indicates that this reach above the Chulitna confluence could be affected by accelerated ice erosion if major jams were to occur more frequently due to hydroelectric dam operations.

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s16/y4

APPENDIX A

Monthly Meteorological Summaries for Weather Stations at Denali, Watana, Devil Canyon, Sherman and Talkeetna

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING December, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	*****	*****	***** -23	***	****	****	***	****	***	**	*****	****	******	1
2	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	2
3	-27.2	-35.4	-31.3	***	****	****	***	****	***	**	*****	****	462	3
4	-24.3	-32.0	-28.2	***	****	****	***	****	***	**	*****	****	460	4
5	-15.4	-28.1	-21.8	***	****	****	***	****	***	**	*****	****	315	5
6	-4.4	-21.9	-13.2	***	****	****	***	****	***	**	*****	****	370	6
7	2.7	-7.7	-2.5	***	****	****	***	****	***	**	*****	****	318	7
8	.6	-5.0	-2.2	***	****	****	***	****	***	**	*****	****	335	8
9	-1.0	-20.7	-10.9	***	****	****	***	****	***	**	*****	****	428	9
10	-18.6	-27.4	-23.0	***	****	****	***	****	***	**	*****	****	379	10
11	-9.8	-25.8	-17.3	***	****	****	***	****	***	**	*****	****	265	11
12	-7.6	-12.6	-10.1	***	****	****	***	****	***	**	*****	****	355	12
13	-3.4	-10.9	-7.2	***	****	****	***	****	***	**	*****	****	308	13
14	-5.5	-16.8	-11.2	***	****	****	***	****	***	**	*****	****	303	14
15	-5.2	-16.3	-10.8	***	****	****	***	****	***	**	*****	****	318	15
16	-12.9	-17.7	-15.3	***	****	****	***	****	***	**	*****	****	299	16
17	-7.8	-15.3	-11.6	***	****	****	***	****	***	**	*****	****	241	17
18	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	18
19	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	19
20	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	20
21	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	21
22	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	22
23	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	23
24	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	24
25	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	25
26	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	26
27	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	27
28	*****	*****	***** -1.2	***	****	****	***	****	***	**	*****	****	******	28
29	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	29
30	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	30
31	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	31
MONTH	2.7	-35.4	-14.4	***	****	****	***	****	***	**	*****	****	5142	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 999.0
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 999.0
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 999.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 999.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING January, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	1
2	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	2
3	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	3
4	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	4
5	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	5
6	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	6
7	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	7
8	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	8
9	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	9
10	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	10
11	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	11
12	-25.9	-32.8	-29.4	***	****	****	***	****	***	77	-32.4	****	******	12
13	-28.3	-36.0	-32.2	***	****	****	***	****	***	75	-35.1	****	******	13
14	-17.6	-32.9	-25.3	***	****	****	***	****	***	80	-32.5	****	******	14
15	-14.7	-24.4	-19.6	***	****	****	***	****	***	**	*****	****	******	15
16	-8.3	-18.2	-13.3	***	****	****	***	****	***	**	*****	****	******	16
17	-7.6	-14.8	-11.2	***	****	****	***	****	***	**	*****	****	******	17
18	-5.8	-14.4	-10.1	***	****	****	***	****	***	**	*****	****	******	18
19	-6.7	-13.6	-10.2	***	****	****	***	****	***	**	*****	****	******	19
20	-8.2	-19.1	-13.7	***	****	****	***	****	***	**	*****	****	******	20
21	-12.6	-23.3	-18.0	***	****	****	***	****	***	**	*****	****	******	21
22	-17.3	-24.7	-21.0	***	****	****	***	****	***	**	*****	****	******	22
23	-16.5	-27.5	-22.0	***	****	****	***	****	***	83	-24.4	****	******	23
24	-8.6	-20.0	-14.3	***	****	****	***	****	***	59	-21.9	****	******	24
25	-13.5	-24.4	-19.0	***	****	****	***	****	***	71	-24.7	****	******	25
26	-9.5	-21.6	-15.6	***	****	****	***	****	***	83	-16.9	****	******	26
27	-8.3	-19.4	-13.9	***	****	****	***	****	***	**	*****	****	******	27
28	-5.8	-14.2	-10.0	***	****	****	***	****	***	**	*****	****	******	28
29	-12.8	-22.6	-17.8	***	****	****	***	****	***	**	*****	****	******	29
30	-8.0	-23.1	-15.6	***	****	****	***	****	***	**	*****	****	******	30
31	-6.5	-13.6	-10.1	***	****	****	***	****	***	**	*****	****	******	31
MONTH	-5.8	-36.0	-17.1	***	****	****	***	****	***	74	-26.3	****	******	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 999.0
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 999.0
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 999.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 999.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING February, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	.7	-14.2	-6.8	***	****	****	***	****	***	**	*****	****	******	1
2	-4.2	-11.8	-8.0	***	****	****	***	****	***	**	*****	****	******	2
3	-3.7	-11.0	-7.4	***	****	****	***	****	***	**	*****	****	240	3
4	-4.6	-11.9	-8.3	***	****	****	***	****	***	**	*****	****	698	4
5	-4.4	-14.2	-9.3	***	****	****	***	****	***	**	*****	****	803	5
6	-3.6	-11.6	-7.6	***	****	****	***	****	***	**	*****	****	743	6
7	-3.2	-8.1	-5.7	***	****	****	***	****	***	**	*****	****	850	7
8	-5.3	-9.9	-7.6	***	****	****	***	****	***	**	*****	****	578	8
9	-9.2	-14.0	-11.6	***	****	****	***	****	***	**	*****	****	770	9
10	-11.9	-22.4	-17.2	***	****	****	***	****	***	**	*****	****	873	10
11	-13.7	-24.9	-19.3	***	****	****	***	****	***	**	*****	****	1378	11
12	-15.7	-26.8	-21.3	***	****	****	***	****	***	**	*****	****	948	12
13	-22.8	-30.0	-26.4	***	****	****	***	****	***	**	*****	****	1555	13
14	-19.2	-31.6	-25.4	***	****	****	***	****	***	**	*****	****	1758	14
15	-16.7	-31.2	-24.0	***	****	****	***	****	***	**	*****	****	1775	15
16	-17.5	-31.4	-24.5	***	****	****	***	****	***	**	*****	****	1845	16
17	-17.6	-31.4	-24.5	***	****	****	***	****	***	**	*****	****	1895	17
18	-14.5	-31.0	-22.8	***	****	****	***	****	***	**	*****	****	1220	18
19	-4.9	-19.1	-12.0	***	****	****	***	****	***	**	*****	****	1995	19
20	-8.3	-19.1	-13.7	***	****	****	***	****	***	**	*****	****	1663	20
21	-5.5	-18.6	-12.1	***	****	****	***	****	***	**	*****	****	1980	21
22	-5.0	-18.1	-11.6	***	****	****	***	****	***	**	*****	****	2130	22
23	-8.9	-22.1	-15.5	***	****	****	***	****	***	**	*****	****	1975	23
24	-3.3	-12.5	-7.9	***	****	****	***	****	***	**	*****	****	1298	24
25	-8.3	-17.6	-13.0	***	****	****	***	****	***	**	*****	****	2080	25
26	-6.6	-15.8	-11.2	***	****	****	***	****	***	**	*****	****	2170	26
27	-8.4	-17.2	-12.8	***	****	****	***	****	***	**	*****	****	1863	27
28	-3.8	-11.4	-7.6	***	0.0	0.0	***	0.0	***	**	*****	****	1318	28
MONTH	.7	-31.6	-14.1	***	0.0	0.0	***	0.0	***	**	*****	****	36403	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 999.0
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 999.0
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 999.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 999.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING March, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-7.7	-18.4	-13.1	***	****	****	***	****	***	**	*****	****	1320	1
2	-11.5	-23.2	-17.4	***	****	****	***	****	***	**	*****	****	1515	2
3	-12.6	-26.2	-19.4	***	****	****	***	****	***	**	*****	****	983	3
4	-12.5	-19.7	-16.1	***	****	****	***	****	***	**	*****	****	1313	4
5	-10.1	-20.0	-15.1	***	****	****	***	****	***	**	*****	****	1178	5
6	-10.1	-20.6	-15.4	***	****	****	***	****	***	**	*****	****	1865	6
7	-9.4	-20.9	-15.2	***	****	****	***	****	***	**	*****	****	2150	7
8	-11.7	-26.4	-19.1	***	****	****	***	****	***	**	*****	****	2333	8
9	-10.7	-26.7	-18.7	***	****	****	***	****	***	**	*****	****	3129	9
10	-8.8	-14.3	-11.6	340	1.5	1.7	257	7.0	NNW	**	*****	****	2085	10
11	-1.7	-13.4	-7.6	174	2.4	3.3	166	8.9	SSE	**	*****	****	2713	11
12	1.8	-12.5	-5.4	126	.1	1.6	165	9.5	NNW	**	*****	****	2318	12
13	-.8	-16.2	-8.5	338	.7	1.2	333	3.8	NNW	**	*****	****	3193	13
14	-4.2	-17.1	-10.7	336	.4	.9	344	3.2	NNW	**	*****	****	2890	14
15	-.9	-15.0	-8.0	172	.5	1.7	165	5.7	S	**	*****	****	2573	15
16	-3.0	-10.6	-6.8	347	1.8	2.0	340	5.7	NNW	**	*****	****	3033	16
17	-5.1	-16.0	-10.6	340	1.1	1.4	336	3.8	NNW	**	*****	****	3610	17
18	-4.9	-21.6	-13.3	342	.8	1.3	350	3.8	NNW	**	*****	****	3330	18
19	-6.4	-19.7	-13.1	335	.6	1.0	330	3.8	NNW	**	*****	****	3388	19
20	-3.4	-16.4	-9.9	244	.1	1.5	160	7.6	N	**	*****	****	3285	20
21	-.9	-15.1	-8.0	341	.7	1.1	186	3.8	N	**	*****	****	3578	21
22	-3.3	-16.6	-10.0	344	.6	1.0	006	2.5	NNW	**	*****	****	3703	22
23	-4.7	-18.0	-11.4	341	.8	1.0	335	3.2	NNW	**	*****	****	3855	23
24	-3.9	-19.8	-11.9	343	.7	1.0	004	3.2	NNW	**	*****	****	3178	24
25	.1	-14.3	-7.1	346	.9	1.3	350	4.4	NNW	**	*****	****	3923	25
26	-3.7	-17.0	-10.4	170	2.2	3.0	176	10.8	S	**	*****	****	3868	26
27	-3.6	-15.9	-9.8	175	1.6	3.2	172	12.7	S	**	*****	****	3933	27
28	-6.3	-17.8	-12.1	348	1.3	1.7	127	5.7	NNW	**	*****	****	3888	28
29	-1.6	-20.0	-10.8	341	.8	1.3	344	3.8	NNW	**	*****	****	4258	29
30	-2.1	-17.8	-10.0	345	.7	1.1	340	3.2	NNW	**	*****	****	4333	30
31	-1.8	-16.9	-9.4	348	1.6	1.8	218	5.1	NNW	**	*****	****	3870	31
MONTH	1.8	-26.7	-11.8	335	.4	1.6	172	12.7	NNW	**	*****	****	90588	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 9.5
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 9.5
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 11.4
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 11.4

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING April, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-1.1	-16.8	-9.0	340	1.6	1.9	342	5.7	NNW	**	*****	0.0	4305	1
2	-.7	-16.5	-8.6	339	1.2	1.6	344	5.1	NNW	**	*****	0.0	4683	2
3	3.8	-14.5	-5.4	151	2.9	3.8	138	23.5	S	**	*****	0.0	4735	3
4	4.5	-4.4	.1	195	2.1	4.0	154	20.3	WSW	**	*****	0.0	2440	4
5	.8	-8.8	-4.0	166	4.1	4.5	152	13.3	SSE	**	*****	0.0	4065	5
6	1.3	-10.9	-4.8	186	.4	1.6	184	7.0	S	**	*****	0.0	5048	6
7	.8	-13.9	-6.6	335	.8	1.4	011	5.1	NNW	**	*****	0.0	4655	7
8	.8	-16.9	-8.1	340	1.0	1.5	346	3.8	NNW	**	*****	0.0	4870	8
9	2.7	-11.7	-4.5	339	.6	1.4	225	5.1	NNW	**	*****	0.0	4615	9
10	-6.7	-18.6	-12.7	001	3.4	3.5	006	6.3	N	**	*****	0.0	5410	10
11	-4.2	-22.2	-13.2	188	1.5	3.2	141	16.5	SW	**	*****	0.0	3783	11
12	4.3	-5.0	-.4	168	3.1	3.8	146	15.2	SSE	**	*****	0.0	4235	12
13	-.6	-9.9	-5.3	344	1.3	1.8	335	5.1	NNW	**	*****	0.0	3398	13
14	1.9	-2.9	-.5	190	4.1	5.0	177	12.7	S	**	*****	.2	5690	14
15	2.1	-3.0	-.5	161	3.9	4.3	155	12.7	SSE	**	*****	.2	4030	15
16	.1	-4.2	-2.1	350	4.0	3.1	339	7.6	NNW	**	*****	0.0	5368	16
17	4.6	-8.2	-1.8	241	.2	2.6	161	11.4	NNE	**	*****	0.0	5550	17
18	2.4	-4.1	-.9	152	4.8	5.4	137	17.8	SSE	**	*****	0.0	5628	18
19	3.1	-2.2	.5	152	6.0	6.5	144	20.3	SE	**	*****	0.0	5908	19
20	5.7	-4.1	.8	176	2.2	3.0	162	14.0	S	**	*****	0.0	5015	20
21	4.2	-5.0	-.4	181	.9	1.6	159	7.6	S	**	*****	0.0	6093	21
22	5.0	-4.2	.4	180	3.3	3.5	167	10.8	S	**	*****	0.0	6340	22
23	5.4	-1.8	1.8	191	1.7	2.0	188	7.6	S	**	*****	0.0	5070	23
24	5.7	-2.4	1.7	346	2.1	2.5	339	8.9	NNW	**	*****	0.0	6920	24
25	12.5	-2.5	5.0	329	.7	1.7	166	5.7	N	**	*****	0.0	6805	25
26	6.4	-3.5	1.5	348	2.8	2.9	006	6.3	NNW	**	*****	0.0	6773	26
27	6.5	-3.3	1.6	359	2.7	2.8	019	5.7	N	**	*****	0.0	6865	27
28	7.8	-4.7	1.6	326	.6	1.2	336	4.4	NNW	**	*****	0.0	5055	28
29	5.4	.2	2.8	358	2.2	2.3	350	6.3	N	**	*****	.4	4015	29
30	4.4	-2.8	.8	353	3.8	3.9	339	8.9	N	**	*****	0.0	7028	30
MONTH	12.5	-22.2	-2.3	166	.4	2.9	138	23.5	NNW	**	*****	.8	154391	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 20.3
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 19.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 19.7
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 17.1

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING May, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	6.1	-5.2	.5	200	1.0	1.7	183	8.3	SSW	**	*****	0.0	6735	1
2	5.0	-.8	2.1	218	.5	1.7	138	9.5	W	**	*****	1.2	3540	2
3	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	3
4	3.8	-4.5	-.4	229	.4	1.1	170	4.4	SW	**	*****	0.0	5198	4
5	5.5	-3.0	1.3	334	.8	1.6	343	5.7	NNW	**	*****	0.0	7088	5
6	6.5	-2.4	2.1	330	.5	1.2	327	3.8	N	**	*****	0.0	5500	6
7	6.8	-3.3	1.8	348	2.5	2.8	342	7.0	NNW	**	*****	0.0	6803	7
8	8.8	-1.7	3.6	346	1.3	1.5	348	4.4	NNW	**	*****	0.0	7570	8
9	9.8	-2.8	3.5	229	.6	1.3	205	4.4	SW	**	*****	0.0	6715	9
10	9.2	-1.6	3.8	203	1.6	2.7	177	7.6	S	**	*****	0.0	7553	10
11	10.2	-2.5	3.9	312	1.1	2.2	262	6.3	NNW	**	*****	0.0	7473	11
12	7.4	.3	3.9	203	1.2	1.8	181	8.3	SSW	**	*****	0.0	4560	12
13	11.3	1.0	6.2	195	1.2	1.5	228	5.7	SSW	**	*****	0.0	5903	13
14	9.8	2.5	6.2	198	1.4	2.2	187	7.0	S	**	*****	0.0	5303	14
15	10.7	1.8	6.3	324	1.0	1.9	171	5.7	NNW	**	*****	0.0	6318	15
16	8.4	1.0	4.7	182	2.4	2.9	175	11.4	S	**	*****	2.0	4553	16
17	5.9	.4	3.2	219	.5	1.4	264	7.0	SSW	**	*****	1.8	3220	17
18	5.7	1.2	3.5	170	.3	1.6	159	7.0	W	**	*****	0.0	3905	18
19	9.0	-1.6	3.7	321	.7	1.6	264	6.3	N	**	*****	0.0	5898	19
20	11.1	3.3	7.2	283	2.0	3.5	233	9.5	NNW	**	*****	0.0	5383	20
21	8.5	1.8	5.2	263	2.4	3.0	263	10.8	WSW	**	*****	0.0	4038	21
22	8.7	2.2	5.5	186	1.5	2.0	164	8.3	SSE	**	*****	.8	4783	22
23	8.5	.6	4.6	143	1.8	2.5	143	12.7	SE	**	*****	1.6	4735	23
24	9.6	1.1	5.4	046	.4	2.5	119	9.9	NNW	**	*****	0.0	5093	24
25	13.1	.1	6.6	343	.7	2.4	298	7.6	N	**	*****	0.0	6223	25
26	7.7	2.4	5.1	185	.8	1.9	223	9.5	S	**	*****	.2	3785	26
27	9.6	0.0	4.8	297	.6	2.1	140	7.6	NNW	**	*****	0.0	4803	27
28	13.9	3.4	8.7	087	.4	1.9	122	11.4	E	**	*****	0.0	4000	28
29	16.1	5.0	10.6	145	3.5	4.0	160	17.1	SE	**	*****	0.0	4430	29
30	21.4	7.7	14.6	177	1.2	2.4	177	11.4	S	**	*****	0.0	5753	30
31	15.0	4.3	9.7	164	3.1	4.2	130	17.1	SSE	**	*****	0.0	4043	31
MONTH	21.4	-5.2	4.9	208	.5	2.2	160	17.1	NNW	**	*****	7.6	160899	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 10.2
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 10.8
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 11.4
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.6

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING September, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	11.1	2.6	6.9	058	.7	1.4	145	5.1	N	**	*****	.2	3498	1
2	11.3	1.2	6.3	250	.7	1.9	247	7.0	E	**	*****	2.2	3938	2
3	7.1	2.1	4.6	337	.4	1.1	251	5.7	N	**	*****	8.2	2098	3
4	10.5	.7	5.6	059	.8	1.6	138	4.4	N	**	*****	0.0	4485	4
5	13.6	2.9	8.3	079	5.6	5.8	094	14.0	E	**	*****	.8	2890	5
6	14.5	5.9	10.2	078	2.8	3.5	082	10.2	E	**	*****	1.2	2930	6
7	9.9	5.1	7.5	269	2.8	2.9	254	7.0	W	**	*****	4.4	2865	7
8	7.4	4.9	6.2	266	1.6	1.8	271	4.4	W	**	*****	2.2	1490	8
9	8.8	4.6	6.7	089	1.7	2.1	087	8.3	E	**	*****	4.6	2265	9
10	8.5	3.4	6.0	050	1.2	1.5	067	4.4	N	**	*****	0.0	2220	10
11	6.6	.6	3.6	257	1.1	1.9	255	8.9	W	**	*****	12.0	1695	11
12	7.6	-.6	3.5	081	2.4	2.8	076	10.8	E	**	*****	2.6	3743	12
13	12.1	1.4	6.8	063	2.3	3.7	055	8.9	ENE	**	*****	18.6	2195	13
14	7.8	5.2	6.5	079	1.7	2.0	073	7.0	ENE	**	*****	12.6	1185	14
15	9.1	6.6	7.9	054	3.5	3.6	069	7.6	NE	**	*****	7.6	542	15
16	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	16
17	7.9	6.0	7.0	296	1.1	1.3	330	3.2	WNW	**	*****	0.0	908	17
18	11.4	6.0	8.7	078	2.1	3.2	111	8.9	E	**	*****	0.0	2305	18
19	8.1	2.6	5.4	269	1.1	1.5	251	5.7	W	**	*****	4.8	1410	19
20	7.3	2.4	4.9	353	.1	1.3	238	4.4	W	**	*****	.6	2145	20
21	10.2	2.1	6.2	079	2.4	3.9	088	11.4	E	**	*****	1.6	1413	21
22	6.5	-1.1	2.7	286	1.2	1.9	248	7.6	W	**	*****	1.0	2720	22
23	6.7	-4.1	1.3	325	.8	1.7	226	5.1	N	**	*****	0.0	3958	23
24	7.9	-5.6	1.2	073	2.2	2.3	075	7.0	E	**	*****	0.0	2960	24
25	10.2	-1.0	4.6	058	1.4	1.9	078	7.0	E	**	*****	0.0	2745	25
26	5.2	.9	3.1	326	.6	1.5	045	5.1	WNW	**	*****	2.8	1798	26
27	6.3	-2.0	2.2	285	1.6	2.2	269	7.0	W	**	*****	.6	2755	27
28	3.1	-4.3	-.6	076	4.3	4.4	083	9.5	ENE	**	*****	2.0	1590	28
29	4.7	.1	2.4	070	2.8	3.0	092	7.6	NE	**	*****	5.8	1730	29
30	2.9	-1.1	.9	274	.6	1.0	261	3.8	W	**	*****	4.4	1568	30
MONTH	14.5	-5.6	5.0	062	.9	2.4	094	14.0	E	**	*****	100.8	67240	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 10.8
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 9.5
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 11.4
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 10.2

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING October, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	3.7	-2.1	.8	218	.1	.6	271	3.8	SE	**	*****	0.0	1830	1
2	2.2	-2.0	.1	062	.9	1.0	110	4.4	N	**	*****	0.0	2270	2
3	1.8	-2.6	-.4	052	2.2	2.4	031	6.3	NE	**	*****	.4	1480	3
4	1.9	-3.3	-.7	049	3.3	3.4	046	7.6	NE	**	*****	0.0	2890	4
5	-.1	-3.5	-1.8	040	4.0	4.1	035	8.9	NNE	**	*****	0.0	2780	5
6	1.1	-3.5	-1.2	049	4.3	4.4	064	8.3	NE	**	*****	0.0	2005	6
7	-.8	-3.8	-2.3	069	3.3	3.8	073	8.9	ENE	**	*****	0.0	985	7
8	-2.3	-5.7	-4.0	260	3.8	3.5	265	8.9	WSW	**	*****	0.0	2229	8
9	-1.2	-10.9	-6.1	276	1.4	1.6	257	4.4	W	**	*****	0.0	1468	9
10	-.9	-7.3	-4.1	297	.6	1.1	266	3.8	W	**	*****	0.0	1085	10
11	-1.9	-9.9	-5.9	***	****	3.5	***	****	***	**	*****	.2	930	11
12	1.8	-4.2	-1.2	062	4.4	4.6	079	11.4	ENE	**	*****	.2	1080	12
13	-3.3	-18.1	-10.7	052	1.5	2.0	029	8.3	N	**	*****	0.0	1435	13
14	-4.1	-14.5	-9.3	068	1.7	1.9	096	5.1	E	**	*****	0.0	1513	14
15	-4.0	-17.2	-10.6	039	1.8	2.2	073	7.6	N	**	*****	0.0	2619	15
16	-3.2	-11.3	-7.3	067	5.1	5.1	086	10.2	ENE	**	*****	0.0	1020	16
17	-.5	-7.6	-4.1	012	1.0	1.4	017	3.8	NNE	**	*****	0.0	1640	17
18	-.3	-11.0	-5.7	036	1.2	1.5	346	3.8	N	**	*****	0.0	2100	18
19	5.1	-6.6	-.8	065	1.2	1.5	037	3.8	E	**	*****	0.0	1056	19
20	4.1	-4.7	-.3	052	2.3	2.7	026	8.9	NNE	**	*****	0.0	******	20
21	-.1	-7.5	-3.8	044	4.7	4.9	036	8.9	NE	**	*****	0.0	******	21
22	-3.3	-12.1	-7.7	052	5.9	6.0	059	10.2	NE	**	*****	0.0	******	22
23	-4.5	-16.0	-10.3	063	5.5	5.7	043	8.9	ENE	**	*****	0.0	******	23
24	-6.4	-16.8	-11.6	066	4.0	4.2	075	8.9	ENE	**	*****	0.0	******	24
25	-4.0	-14.6	-9.3	086	2.2	2.5	050	6.3	ENE	**	*****	0.0	******	25
26	-11.1	-22.7	-16.9	080	3.2	3.6	097	8.9	E	**	*****	0.0	******	26
27	-17.3	-27.9	-22.6	054	2.7	2.9	082	8.3	ENE	**	*****	0.0	1550	27
28	-16.2	-21.2	-18.7	072	3.9	4.0	072	9.5	ENE	**	*****	3.0	730	28
29	-10.3	-22.3	-16.3	302	.7	1.4	301	3.2	WNW	**	*****	.4	1505	29
30	-15.1	-32.8	-24.0	***	****	1.6	***	****	***	**	*****	0.0	1400	30
31	-13.1	-24.3	-18.7	056	6.2	4.4	056	10.2	NE	**	*****	0.0	1035	31
MONTH	5.1	-32.8	-7.6	056	2.7	3.0	079	11.4	ENE	**	*****	4.2	38729	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 8.9
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 7.6
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 8.9

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING November, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-3.0	-14.9	-9.0	072	6.3	6.4	073	14.0	ENE	**	*****	0.0	1010	1
2	-1.4	-10.9	-6.2	068	1.5	2.0	064	6.3	E	**	*****	0.0	585	2
3	-4.3	-13.4	-8.9	071	2.7	2.9	076	7.6	ENE	**	*****	0.0	588	3
4	-4.3	-9.2	-6.8	060	4.0	4.1	068	10.2	ENE	**	*****	0.0	913	4
5	-8.4	-15.7	-12.1	052	2.3	2.4	057	5.1	NE	**	*****	0.0	965	5
6	-11.3	-20.5	-15.9	065	1.2	1.4	045	4.4	E	**	*****	0.0	1529	6
7	-12.6	-21.9	-17.3	064	3.6	3.7	064	9.5	ENE	**	*****	0.0	1515	7
8	-11.2	-16.5	-13.9	064	4.3	4.8	064	11.4	ENE	**	*****	0.0	523	8
9	-8.2	-18.5	-13.4	302	.8	1.2	288	5.7	WNW	**	*****	0.0	495	9
10	-8.3	-16.7	-12.5	064	3.9	4.0	067	9.5	ENE	**	*****	.2	573	10
11	-5.4	-9.5	-7.5	063	1.9	2.0	075	7.6	ENE	**	*****	0.0	640	11
12	-1.6	-7.1	-4.4	066	5.9	6.0	082	12.1	ENE	68	-9.1	0.0	750	12
13	-1.5	-6.0	-3.8	054	3.2	3.6	086	8.9	NE	73	-7.3	0.0	643	13
14	-4.2	-10.2	-7.2	025	1.2	1.3	008	3.2	N	**	*****	0.0	798	14
15	-5.8	-17.6	-11.7	065	1.5	1.7	089	4.4	ENE	68	-14.9	0.0	920	15
16	-10.2	-19.4	-14.8	075	1.7	1.8	073	5.7	ENE	72	-20.4	0.0	1003	16
17	-16.2	-22.7	-19.5	077	2.3	2.3	073	4.4	E	63	-25.1	0.0	990	17
18	-14.5	-24.5	-19.5	066	2.8	3.0	081	8.3	ENE	47	-28.9	0.0	1003	18
19	-16.9	-24.7	-20.8	070	5.7	5.8	074	11.4	ENE	46	-28.6	0.0	785	19
20	-13.3	-17.9	-15.6	091	2.4	2.5	071	7.6	E	52	-23.2	0.0	505	20
21	-6.6	-15.1	-10.9	061	3.6	3.8	052	7.6	NE	58	-16.4	0.0	520	21
22	-5.1	-11.2	-8.2	056	1.8	2.0	051	5.1	E	62	-14.0	0.0	459	22
23	-2.7	-5.5	-4.1	056	4.3	4.4	059	7.0	ENE	71	-8.5	0.0	435	23
24	-1.6	-4.2	-2.9	058	4.5	4.5	082	7.0	NE	**	*****	0.0	620	24
25	-3.3	-10.9	-7.1	076	4.5	4.6	081	9.5	ENE	73	-11.6	0.0	515	25
26	-5.8	-11.6	-8.7	062	5.7	5.7	067	10.8	ENE	66	-13.9	0.0	558	26
27	-3.8	-14.5	-9.2	066	2.3	2.4	065	7.0	ENE	73	-9.2	0.0	518	27
28	-7.2	-16.6	-11.9	071	1.6	1.7	060	4.4	E	**	*****	0.0	558	28
29	-7.0	-9.4	-8.2	058	3.4	3.5	055	7.6	NE	**	*****	0.0	385	29
30	-6.9	-15.2	-11.1	035	3.8	4.1	030	10.2	NNE	77	-16.6	0.0	380	30
MONTH	-1.4	-24.7	-10.7	063	3.1	3.3	073	14.0	ENE	62	-16.5	.2	21573	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 12.1
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 11.4
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 13.3
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 12.1

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING December, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-14.4	-19.7	-17.1	032	5.5	5.7	025	10.8	NNE	66	-21.9	0.0	448	1
2	-17.1	-23.9	-20.5	070	5.3	5.4	071	10.2	ENE	59	-24.8	0.0	498	2
3	-17.7	-24.2	-21.0	085	4.5	4.8	074	9.5	ENE	60	-26.3	.2	483	3
4	-15.1	-24.1	-19.6	063	5.6	5.6	063	10.2	ENE	60	-25.6	0.0	463	4
5	-7.4	-15.6	-11.5	061	6.6	6.7	062	10.2	ENE	72	-15.1	0.0	395	5
6	-5.3	-10.8	-8.1	057	6.5	6.6	057	12.1	NE	69	-13.4	.8	458	6
7	-.9	-5.9	-3.4	082	7.1	7.2	089	14.6	E	80	-8.4	2.8	358	7
8	-1.0	-4.8	-2.9	079	3.6	3.8	079	12.1	ENE	**	*****	.4	360	8
9	-2.4	-17.2	-9.8	059	.8	2.0	279	7.0	ENE	**	*****	0.0	420	9
10	-8.3	-18.4	-13.4	076	3.4	3.5	066	8.9	E	66	-15.5	0.0	375	10
11	-7.6	-10.2	-8.9	063	6.6	6.7	067	13.3	ENE	66	-14.3	0.0	345	11
12	-5.8	-9.2	-7.5	066	6.8	7.1	084	14.0	ENE	69	-12.4	0.0	368	12
13	-3.3	-6.9	-5.1	070	5.7	6.0	077	12.1	ENE	**	*****	0.0	375	13
14	-2.9	-10.8	-6.9	077	3.6	3.8	091	8.9	E	70	-12.1	0.0	358	14
15	-2.8	-10.6	-6.7	066	5.3	5.4	074	9.5	ENE	70	-9.2	0.0	383	15
16	-4.5	-11.8	-8.2	065	3.5	5.6	075	12.1	ENE	70	-11.0	0.0	380	16
17	-6.2	-12.2	-9.2	068	2.3	2.4	054	7.6	E	75	-10.5	0.0	355	17
18	-7.3	-15.9	-11.6	067	3.1	3.1	067	7.6	ENE	**	*****	0.0	363	18
19	-8.7	-14.6	-11.7	059	5.7	5.7	055	10.2	ENE	69	-15.9	0.0	350	19
20	-8.9	-17.5	-13.2	066	4.2	4.4	049	9.5	ENE	65	-17.6	0.0	410	20
21	-14.8	-21.9	-18.4	077	2.2	2.3	069	5.1	ENE	83	-21.4	0.0	463	21
22	-14.4	-22.7	-18.6	075	4.2	4.4	079	9.5	ENE	74	-22.4	0.0	475	22
23	-14.3	-20.0	-17.2	062	5.5	5.6	061	9.5	ENE	64	-21.2	0.0	405	23
24	-9.4	-18.0	-13.7	076	3.3	3.4	053	7.6	E	69	-18.3	0.0	390	24
25	-11.6	-18.1	-14.9	073	3.1	3.3	055	9.5	E	85	-17.5	0.0	385	25
26	-2.5	-13.4	-8.0	062	6.6	6.7	078	11.4	ENE	78	-13.6	0.0	358	26
27	.4	-3.8	-1.7	085	5.7	5.8	098	12.7	E	**	*****	0.0	303	27
28	2.7	-.3	1.2	083	4.1	4.2	080	9.5	E	**	*****	2.8	290	28
29	2.6	-3.1	-.3	078	3.4	3.7	075	10.2	E	**	*****	0.0	348	29
30	-1.6	-11.8	-6.7	088	.1	1.9	265	6.3	E	**	*****	0.0	313	30
31	-4.1	-12.5	-8.3	061	2.3	2.5	050	7.0	ENE	**	*****	0.0	400	31
MONTH	2.7	-24.2	-10.4	068	4.4	4.7	089	14.6	ENE	69	-16.7	7.0	12068	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 10.8
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 12.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 12.7
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 10.8

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING January, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	4.0	-5.7	-.9	064	5.3	5.4	072	10.2	ENE	**	*****	0.0	425	1
2	-4.2	-7.1	-5.7	062	4.6	4.8	059	8.3	ENE	**	*****	0.0	410	2
3	-6.6	-11.5	-9.1	053	4.7	4.8	053	8.3	NE	58	-17.3	1.6	348	3
4	-10.6	-25.7	-18.2	076	3.1	3.3	080	7.0	E	51	-25.7	0.0	495	4
5	-20.2	-28.6	-24.4	091	3.6	3.7	086	7.0	E	55	-30.9	0.0	495	5
6	-20.6	-26.1	-23.4	051	6.0	6.2	040	11.4	NE	54	-28.6	0.0	435	6
7	-22.1	-27.2	-24.7	052	5.9	6.0	062	12.1	NE	56	-30.3	0.0	468	7
8	-21.8	-28.6	-25.2	076	5.0	5.3	060	10.2	ENE	54	-32.8	0.0	515	8
9	-27.0	-34.4	-30.7	088	2.9	3.1	078	8.9	ESE	51	-37.5	0.0	510	9
10	-27.5	-27.5	-27.5	093	4.5	4.5	093	7.0	E	55	-33.8	****	240	10
11	-17.9	-20.8	-19.4	051	4.0	4.9	010	8.9	E	28	-34.4	0.0	240	11
12	-20.5	-25.0	-22.8	062	5.8	5.9	052	10.8	ENE	40	-32.7	0.0	598	12
13	-21.1	-25.2	-23.2	065	7.2	7.3	059	13.3	ENE	46	-32.5	0.0	573	13
14	-14.1	-24.6	-19.4	068	5.0	5.2	069	11.4	ENE	49	-27.0	0.0	505	14
15	-4.9	-20.9	-12.9	069	3.9	4.1	062	9.5	ENE	60	-19.3	0.0	450	15
16	-6.1	-10.2	-8.2	066	4.8	4.8	066	10.2	ENE	65	-13.7	0.0	485	16
17	-5.8	-12.6	-9.2	044	2.0	2.3	067	8.3	N	70	-13.3	0.0	475	17
18	-4.2	-6.9	-5.6	057	5.9	6.2	075	12.1	ENE	68	-10.4	0.0	560	18
19	-6.0	-10.9	-8.5	066	.5	2.8	072	9.5	ENE	68	-12.9	1.2	453	19
20	-8.0	-10.5	-9.3	047	5.5	5.5	061	8.9	NE	67	-14.2	0.0	565	20
21	-7.4	-15.2	-11.3	047	5.1	5.2	056	8.3	NE	46	-19.4	0.0	720	21
22	-3.8	-17.2	-10.5	076	3.6	3.7	083	9.5	ENE	39	-22.7	0.0	760	22
23	-6.0	-16.4	-11.2	075	3.6	3.7	070	8.3	E	31	-26.7	0.0	790	23
24	-8.4	-13.7	-11.1	062	6.0	6.2	063	12.1	ENE	33	-24.9	0.0	815	24
25	-8.7	-14.6	-11.7	065	7.4	7.5	065	13.3	ENE	39	-23.8	0.0	750	25
26	-6.7	-11.3	-9.0	069	7.4	7.6	065	14.6	ENE	52	-16.9	0.0	648	26
27	-6.6	-13.6	-10.2	072	3.1	3.3	075	9.5	ENE	64	-15.0	0.0	598	27
28	-4.7	-10.7	-7.7	076	1.4	1.6	095	3.8	E	**	*****	0.0	693	28
29	-8.1	-15.8	-12.0	073	2.2	2.4	097	5.7	E	75	-14.8	0.0	688	29
30	-6.1	-14.2	-10.2	058	6.4	6.4	057	10.2	ENE	77	-12.6	0.0	653	30
31	-2.2	-6.9	-4.6	063	5.2	5.4	075	10.8	ENE	66	-9.8	0.0	920	31
MONTH	4.0	-34.4	-14.1	064	4.5	4.8	065	14.6	ENE	53	-22.6	2.8	17675	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 11.4
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 14.0
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 14.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 12.1

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING February, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	.3	-10.2	-5.0	069	4.8	5.0	069	13.3	NE	59	-10.5	0.0	913	1
2	-1.7	-5.3	-3.5	063	5.3	5.5	070	10.8	ENE	77	-7.3	0.0	893	2
3	-2.8	-5.7	-4.3	059	5.0	5.1	074	10.8	NE	69	-9.3	0.0	813	3
4	-2.7	-6.3	-4.5	071	5.5	5.6	077	12.1	ENE	62	-10.8	0.0	833	4
5	-2.4	-9.4	-5.9	060	4.7	4.9	071	14.0	ENE	61	-11.7	0.0	1108	5
6	-1.7	-10.7	-6.2	064	4.6	4.9	061	11.4	ENE	64	-9.3	0.0	1100	6
7	-4.4	-7.4	-5.9	028	.9	2.5	077	8.3	WNW	76	-8.8	0.0	931	7
8	-5.1	-13.5	-9.3	341	1.2	1.4	290	3.2	N	**	*****	0.0	687	8
9	-7.5	-15.9	-11.7	063	1.2	1.7	086	8.0	E	60	-17.5	0.0	783	9
10	-11.1	-17.4	-14.3	074	1.7	1.8	079	5.7	E	68	-18.0	0.0	751	10
11	-13.6	-20.8	-17.2	075	2.1	2.4	073	5.1	E	68	-22.4	0.0	828	11
12	-12.7	-22.9	-17.8	074	1.9	1.9	096	5.1	E	64	-24.6	0.0	935	12
13	-14.8	-25.4	-20.1	063	1.7	1.9	066	3.8	ENE	63	-27.3	0.0	1912	13
14	-13.2	-25.4	-19.3	072	2.8	2.9	073	8.9	ENE	59	-24.7	0.0	1973	14
15	-11.4	-15.1	-13.3	076	7.1	7.1	078	11.4	ENE	52	-21.1	0.0	1558	15
16	-12.0	-15.3	-13.7	073	8.0	8.0	076	11.4	ENE	47	-22.4	0.0	1630	16
17	-14.0	-19.4	-16.7	077	6.6	6.7	076	11.4	ENE	45	-25.6	0.0	1685	17
18	-10.9	-18.0	-14.5	063	7.1	7.2	065	11.4	ENE	56	-21.7	0.0	1245	18
19	-5.1	-13.6	-9.4	051	4.0	4.2	061	8.9	ENE	73	-13.6	0.0	1690	19
20	-5.0	-12.9	-9.0	066	5.6	5.7	077	9.5	ENE	60	-14.3	0.0	1740	20
21	-4.1	-12.3	-8.2	067	4.0	4.1	066	8.3	ENE	58	-14.0	0.0	1845	21
22	-1.1	-11.8	-6.5	063	3.8	4.0	065	9.5	ENE	65	-10.9	0.0	1920	22
23	-3.7	-12.3	-8.0	066	5.6	5.7	061	11.4	ENE	56	-14.3	0.0	1908	23
24	-3.4	-8.6	-6.0	050	2.9	3.2	068	15.2	ENE	75	-9.8	0.0	1253	24
25	-3.6	-14.4	-9.0	061	3.7	3.9	062	8.9	NE	61	-12.3	0.0	2365	25
26	-4.8	-9.0	-6.9	055	6.4	6.5	060	10.8	NE	62	-12.6	0.0	2118	26
27	-3.9	-12.8	-8.4	056	3.0	3.1	064	8.9	ENE	61	-13.7	0.0	1928	27
28	-4.2	-9.2	-6.7	059	1.0	1.1	073	3.8	ENE	66	-13.6	0.0	1650	28
MONTH	.3	-25.4	-10.0	065	4.1	4.3	068	15.2	ENE	61	-15.6	0.0	38982	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 8.3
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 14.6
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 8.3

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING March, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-2.6	-13.6	-8.2	027	1.0	1.2	357	4.4	N	**	*****	****	1330	1
2	-8.1	-17.4	-12.8	034	1.8	2.0	061	5.7	NNE	63	-16.9	****	2450	2
3	-11.6	-21.3	-16.5	050	4.0	4.4	066	8.9	ENE	68	-20.3	****	2748	3
4	-12.4	-20.2	-16.3	051	3.3	3.8	064	8.3	ENE	68	-19.9	****	2001	4
5	-7.8	-16.4	-12.1	068	3.7	3.8	078	7.6	ENE	64	-16.4	****	1725	5
6	-6.5	-15.4	-11.0	070	5.3	5.3	072	10.2	ENE	60	-15.6	****	2503	6
7	-4.9	-15.2	-10.1	053	2.6	2.7	072	6.3	ENE	58	-16.7	****	2638	7
8	-5.6	-17.5	-11.6	074	3.2	3.2	074	7.6	ENE	53	-19.5	****	3025	8
9	-7.8	-20.6	-14.2	072	3.8	3.9	070	12.1	ENE	49	-22.5	****	4227	9
10	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	10
11	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	11
12	1.8	-1.8	0.0	042	3.6	3.6	051	5.7	NE	53	-8.0	****	3960	12
13	1.0	-8.9	-4.0	054	4.1	4.2	017	6.8	ENE	50	-10.2	****	2910	13
14	-1.3	-6.3	-3.8	052	2.5	2.6	066	3.8	NE	58	-10.6	****	2655	14
15	-.7	-8.4	-4.6	043	2.8	3.0	036	6.8	NE	66	-8.6	****	1287	15
16	.6	-9.8	-4.6	044	2.2	2.3	048	3.8	NE	61	-10.2	****	1673	16
17	-.5	-9.2	-4.9	048	3.0	3.2	011	6.2	NE	54	-12.1	****	3378	17
18	-.8	-7.1	-4.0	054	3.2	3.3	054	5.7	NE	56	-10.8	****	4926	18
19	-3.0	-10.1	-6.6	060	4.0	4.0	063	5.7	NE	58	-12.8	****	2400	19
20	-2.8	-7.8	-5.3	059	3.3	3.5	078	6.3	ENE	57	-11.8	****	4110	20
21	-1.6	-9.1	-5.4	054	4.3	4.4	075	7.6	ENE	53	-12.7	****	3471	21
22	-1.9	-9.8	-5.9	054	4.2	4.3	061	6.3	NE	52	-12.9	****	4920	22
23	-2.5	-11.7	-7.1	032	2.4	2.7	056	6.3	NE	50	-15.4	****	4152	23
24	-2.6	-14.9	-8.8	058	3.0	3.1	064	6.3	NE	56	-13.0	****	3249	24
25	-2.4	-8.7	-5.6	058	4.4	4.4	069	8.3	ENE	55	-13.1	****	4112	25
26	-2.6	-8.9	-5.8	055	5.4	5.4	060	10.8	NE	53	-13.5	****	3903	26
27	-4.3	-9.1	-6.7	061	6.6	6.7	053	11.4	ENE	51	-15.2	****	4220	27
28	-2.0	-13.4	-7.7	048	3.3	3.4	054	7.0	NE	54	-14.7	****	4320	28
29	-1.4	-10.8	-6.1	059	3.8	4.0	070	8.9	ENE	58	-13.1	****	4523	29
30	-.5	-13.4	-7.0	055	2.7	2.9	074	5.7	ENE	60	-13.0	****	4778	30
31	.9	-10.1	-4.6	051	2.8	2.9	061	6.3	ENE	62	-10.0	****	4500	31
MONTH	1.8	-21.3	-7.6	057	3.5	3.7	070	12.1	ENE	58	-14.0	****	96091	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 8.9
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 10.8
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 8.9

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING April, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	1.8	-10.9	-4.6	058	2.6	2.7	069	6.3	ENE	58	-9.1	0.0	4918	1
2	3.6	-11.1	-3.8	046	2.3	2.5	068	7.0	NE	54	-11.6	0.0	5065	2
3	.8	-11.3	-5.3	068	3.9	4.1	071	13.3	ENE	59	-10.5	0.0	5130	3
4	1.7	-3.9	-1.1	048	1.1	4.9	274	14.6	ENE	60	-6.3	2.0	2143	4
5	1.0	-7.0	-3.0	051	2.4	2.8	073	8.3	ENE	63	-6.5	0.0	4013	5
6	.3	-10.3	-5.0	031	1.8	2.1	007	5.1	NNE	58	-10.9	0.0	5288	6
7	.6	-10.6	-5.0	033	1.8	2.1	009	4.4	NNE	57	-11.9	0.0	5383	7
8	2.2	-10.4	-4.1	051	.6	1.3	249	4.4	NE	58	-11.6	0.0	4303	8
9	2.6	-10.7	-4.1	322	.6	1.6	270	5.7	N	69	-12.1	.2	3473	9
10	-4.6	-15.9	-10.3	028	1.9	2.1	022	5.1	NE	54	-17.7	0.0	5653	10
11	-8.2	-17.0	-12.6	069	4.0	4.1	078	10.8	ENE	63	-18.4	0.0	5615	11
12	.4	-1.0	-.3	054	3.6	3.7	069	5.7	ENE	60	-6.9	0.0	10829	12
13	0.0	0.0	0.0	050	1.7	1.7	055	1.9	NE	**	*****	0.0	7440	13
14	5.1	0.0	2.6	033	1.2	1.4	035	3.2	NNE	46	-7.5	.2	13920	14
15	.1	-3.2	-1.6	076	2.7	2.8	099	6.3	ENE	**	*****	0.0	1271	15
16	1.4	-5.0	-1.8	045	2.5	2.8	061	9.5	ENE	62	-6.0	0.0	4878	16
17	6.8	-5.8	.5	320	.9	1.7	245	7.0	WNW	53	-9.9	0.0	5600	17
18	1.8	-4.2	-1.2	071	3.0	3.7	083	10.2	ENE	58	-7.1	0.0	4050	18
19	3.4	-3.1	.2	057	3.0	3.9	079	11.4	ENE	47	-10.0	0.0	5571	19
20	3.4	-4.2	-.4	067	2.9	3.2	081	8.9	ENE	60	-7.4	0.0	4740	20
21	3.7	-4.4	-.4	044	2.4	2.7	080	7.0	NE	53	-6.3	0.0	6108	21
22	6.5	-3.0	1.8	036	.9	1.7	094	5.7	ENE	56	-4.8	0.0	5863	22
23	4.9	-2.1	1.4	302	.4	1.3	255	5.1	E	63	-2.7	0.0	5160	23
24	8.3	-1.2	3.6	040	2.0	2.2	076	6.3	NE	49	-4.6	0.0	6968	24
25	10.1	1.3	5.7	052	2.6	3.0	060	7.0	ENE	51	-3.4	0.0	7031	25
26	8.9	-1.8	3.6	002	1.7	1.8	001	4.4	N	50	-3.9	0.0	8238	26
27	8.7	-2.2	3.3	336	1.6	2.0	265	6.3	N	49	-3.7	.2	6895	27
28	7.6	-2.8	2.4	344	.9	1.5	001	4.4	N	57	-1.8	0.0	4610	28
29	6.4	.3	3.4	275	.7	.9	219	3.2	W	**	*****	0.0	4080	29
30	7.7	-1.1	3.3	035	1.7	1.9	011	5.1	NNE	40	-8.3	0.0	7525	30
MONTH	10.1	-17.0	-1.1	045	1.7	2.5	274	14.6	ENE	55	-8.2	2.6	171764	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 11.4
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 12.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 14.6
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 14.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING May, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	8.0	-3.6	2.2	069	2.7	3.2	081	8.9	ENE	52	-6.1	0.0	6705	1
2	2.1	-.8	.7	279	1.1	1.9	262	5.7	WSW	**	*****	6.6	2233	2
3	3.3	-1.6	.9	272	1.5	1.9	214	5.1	WSW	**	*****	.6	5448	3
4	5.1	-2.1	1.5	064	3.6	3.3	070	7.6	ENE	**	*****	.2	6218	4
5	6.0	-1.8	2.1	037	2.3	2.6	067	7.0	NE	58	-3.5	0.0	6073	5
6	7.1	-3.3	1.9	072	2.0	2.6	126	7.6	NNE	54	-3.8	0.0	7523	6
7	10.0	-2.4	3.8	023	2.8	3.1	000	7.0	NNE	45	-5.2	0.0	7580	7
8	11.1	-1.4	4.9	010	1.6	1.9	003	4.4	N	46	-5.3	0.0	6753	8
9	9.4	-1.8	3.8	332	1.5	2.0	316	5.1	N	51	-2.4	0.0	5120	9
10	10.2	.1	5.2	334	1.6	2.3	324	8.3	NNW	41	-6.5	0.0	7320	10
11	11.6	-2.5	4.6	015	1.5	2.1	133	6.3	N	41	-6.6	0.0	7833	11
12	9.4	.8	5.1	063	2.3	2.9	109	8.3	NNE	54	-2.2	0.0	5755	12
13	12.6	2.6	7.6	049	1.8	2.4	020	7.0	NNE	47	-1.4	0.0	5215	13
14	11.1	3.1	7.1	270	1.7	2.2	240	7.0	W	50	-.3	0.0	5098	14
15	11.1	2.1	6.6	300	1.5	2.0	330	5.7	WNW	49	-1.0	0.0	5500	15
16	9.6	.1	4.9	084	3.1	3.7	083	9.5	ENE	54	-1.8	.2	5525	16
17	6.4	1.0	3.7	262	2.6	2.8	254	9.3	W	**	*****	1.2	3960	17
18	6.7	.6	3.7	274	2.2	2.6	252	7.6	WNW	63	-.5	0.0	4963	18
19	9.8	-.6	4.6	261	1.8	2.6	245	8.9	W	47	-3.0	0.0	3053	19
20	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	20
21	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	21
22	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	22
23	8.1	1.8	5.0	294	1.0	2.3	080	7.0	W	**	*****	.4	1357	23
24	10.6	.7	5.7	055	1.8	2.5	099	7.6	N	50	-2.9	.6	6990	24
25	12.7	-1.2	5.8	272	1.9	2.9	236	8.9	W	52	-1.5	0.0	7223	25
26	8.6	2.1	5.4	254	1.3	2.0	275	10.2	WSW	**	*****	2.8	4030	26
27	10.4	1.2	5.8	072	1.5	1.9	084	5.7	ENE	54	-.3	0.0	4700	27
28	15.6	4.6	10.1	073	2.6	3.4	085	8.3	NE	50	2.2	0.0	6905	28
29	17.6	6.7	12.2	085	3.5	4.0	086	9.5	E	50	4.4	0.0	4425	29
30	20.1	7.6	13.9	065	1.3	3.2	092	10.2	E	54	6.5	0.0	4690	30
31	12.1	5.8	9.0	260	2.7	3.0	257	7.6	W	**	*****	2.6	4113	31
MONTH	20.1	-3.6	5.3	021	.7	2.6	275	10.2	N	50	-2.0	15.2	157304	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 2.5
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 9.5
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 3.8

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING September, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. G'ST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	12.7	4.5	8.6	258	.0	.9	128	3.2	NNE	46	-3.2	0.0	2670	1
2	11.1	4.3	7.7	062	.1	1.1	161	3.8	ESE	49	-2.9	3.4	2358	2
3	8.5	4.9	6.7	093	.3	.7	060	3.2	NNE	57	-2.2	9.8	1650	3
4	11.2	3.8	7.5	069	.3	1.0	057	3.8	ESE	39	-6.6	.2	2565	4
5	15.4	3.1	9.3	096	2.4	2.6	096	9.5	E	27	-8.6	0.0	2105	5
6	15.5	7.1	11.3	046	.6	2.0	020	8.3	NNE	27	-7.5	0.0	1685	6
7	11.7	6.8	9.3	284	.5	.9	300	4.4	WNW	44	-2.6	4.6	2110	7
8	9.2	6.3	7.8	243	.2	.5	321	2.5	SSW	44	-3.8	0.0	888	8
9	10.2	4.3	7.3	173	.1	.8	291	3.8	SE	54	-1.4	7.8	1310	9
10	11.1	3.2	7.2	102	.4	.9	062	2.5	ENE	46	-4.5	.2	2130	10
11	5.8	2.2	4.0	076	.0	.8	297	4.4	SW	62	-2.6	6.4	988	11
12	9.4	-1.4	4.0	107	.6	.9	071	4.4	ENE	39	-9.4	4.6	2923	12
13	8.9	3.0	6.0	242	.5	.8	260	3.2	WSW	57	-.7	31.0	1330	13
14	8.9	6.4	7.7	147	.1	.6	041	2.5	W	61	.9	14.8	1010	14
15	15.5	6.4	11.0	266	.2	1.0	341	6.3	WSW	47	-.3	21.8	2390	15
16	9.7	3.5	6.6	259	1.5	1.9	281	7.6	W	36	-7.4	6.8	2583	16
17	7.2	1.6	4.4	101	.1	.9	138	3.2	ESE	72	.0	4.4	1432	17
18	11.1	2.7	6.9	261	.2	1.0	288	3.2	WSW	79	2.9	4.0	1628	18
19	8.3	4.3	6.3	158	.2	.7	274	3.2	SE	92	5.4	14.4	775	19
20	7.4	3.9	5.7	070	.1	.8	297	3.8	ENE	89	3.1	1.4	1213	20
21	11.4	3.2	7.3	188	.3	.9	314	5.1	ESE	67	-1.7	.6	1285	21
22	6.6	-.4	3.1	255	.1	1.1	311	4.4	WNW	78	-2.4	1.2	1530	22
23	8.1	-2.8	2.7	212	.6	1.0	285	3.8	SSW	47	-10.2	0.0	2788	23
24	8.6	-2.9	2.9	103	.4	1.1	120	3.2	ENE	75	-1.9	0.0	2075	24
25	9.9	-1.1	4.4	203	.2	.9	076	3.2	S	59	-3.3	0.0	1825	25
26	6.2	1.8	4.0	158	.1	.7	318	3.8	WSW	56	-7.4	4.2	1120	26
27	7.3	-1.2	3.1	198	.2	.9	247	3.2	S	26	-16.7	1.8	1565	27
28	6.1	-3.1	1.5	129	.7	.9	109	4.4	ESE	48	-10.2	5.2	1130	28
29	6.9	1.2	4.1	136	.6	.9	112	5.1	SSE	74	1.3	6.6	1250	29
30	5.5	.6	3.1	321	.2	.7	323	2.5	NNW	47	-6.9	2.2	1190	30
MONTH	15.5	-3.1	6.0	139	.1	.7	096	9.5	ESE	52	-3.7	156.6	51505	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.1
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 5.1
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.6

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING October, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	3.6	.6	2.1	216	.1	.7	278	2.5	WNW	70	-4.6	****	1123	1
2	5.5	-.7	2.4	069	.3	.8	324	3.8	SE	48	-13.7	****	1688	2
3	4.7	-1.5	1.6	013	.6	1.0	017	8.3	NNE	66	-4.8	****	1725	3
4	4.1	-4.2	-.1	133	1.0	1.2	117	4.4	SSE	67	-5.3	****	1855	4
5	3.3	-2.8	.3	075	1.3	2.4	030	10.2	ESE	56	-7.7	****	1940	5
6	4.5	-6.1	-.8	146	.9	1.2	026	4.4	S	58	-8.2	****	1790	6
7	.9	-2.9	-1.0	127	.5	1.1	139	3.8	ESE	48	-14.0	****	475	7
8	-.5	-4.2	-2.4	280	.3	1.0	255	4.4	WSW	43	-18.1	****	980	8
9	.3	-2.7	-1.2	292	.6	.7	307	2.5	WNW	4	-37.2	****	375	9
10	-1.3	-5.0	-3.2	308	.9	1.0	323	3.8	NW	71	-11.8	****	383	10
11	0.0	-6.3	-3.2	120	.9	1.1	117	5.1	ESE	77	-7.5	****	378	11
12	1.8	-1.3	.3	223	.4	.7	314	3.8	SW	23	-25.1	****	395	12
13	-.8	-5.1	-3.0	189	.3	.6	343	3.8	S	61	-14.7	****	428	13
14	-1.3	-9.2	-5.3	117	1.1	1.1	129	3.2	ESE	78	-7.2	****	643	14
15	-3.1	-13.2	-8.2	109	1.4	1.7	139	4.4	SE	85	-10.8	****	683	15
16	-1.8	-8.5	-5.2	103	1.2	1.3	078	3.8	E	82	-7.7	****	345	16
17	2.5	-8.2	-2.9	137	.6	.9	125	3.2	SSW	26	-29.6	****	478	17
18	.7	-10.6	-5.0	101	.8	1.1	105	3.8	E	55	-17.0	****	638	18
19	-.9	-5.5	-3.2	058	.6	.9	110	2.5	NNE	20	-33.8	****	355	19
20	-2.4	-11.4	-6.9	117	1.6	1.7	110	5.7	ESE	77	-9.7	****	773	20
21	-5.7	-13.3	-9.5	044	1.9	2.7	015	11.4	NNE	65	-14.7	****	928	21
22	-4.5	-14.6	-9.6	134	1.3	1.5	116	6.3	ESE	60	-14.8	****	888	22
23	-7.1	-12.5	-9.8	119	2.3	2.4	103	7.0	ESE	60	-16.2	****	755	23
24	-8.0	-13.2	-10.6	109	2.0	2.1	111	5.1	ESE	59	-17.0	****	870	24
25	-7.4	-18.1	-12.8	130	1.7	1.8	122	4.4	SE	70	-16.6	****	788	25
26	-11.3	-19.4	-15.4	124	1.4	1.6	100	4.4	ESE	58	-22.5	****	720	26
27	-14.8	-23.4	-19.1	102	1.6	1.7	102	5.7	E	66	-23.4	****	663	27
28	-11.3	-15.1	-13.2	103	2.0	2.1	104	5.1	E	82	-15.8	****	438	28
29	-7.4	-19.2	-13.3	115	.9	1.2	141	4.4	SE	85	-16.2	****	630	29
30	-15.3	-22.8	-19.1	076	1.8	1.9	073	4.4	ENE	81	-22.2	****	545	30
31	-9.0	-22.7	-15.9	081	2.0	2.1	066	4.4	ENE	79	-20.1	****	585	31
MONTH	5.5	-23.4	-6.2	104	.9	1.4	015	11.4	ESE	65	-15.7	****	25252	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 9.5
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 9.5
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 10.8
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 11.4

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING November, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	.2	-9.1	-4.5	120	1.5	1.8	113	7.6	ESE	73	-7.5	****	653	1
2	-.6	-9.6	-5.1	120	.6	.9	085	3.2	S	75	-5.8	****	615	2
3	-2.7	-12.9	-7.0	116	.5	.9	070	3.8	ENE	70	-14.5	****	440	3
4	-.3	-5.5	-2.9	125	.9	1.1	170	6.3	ESE	75	-7.2	****	568	4
5	-2.6	-14.3	-8.5	135	.6	.8	132	2.5	SE	89	-8.7	****	605	5
6	-11.7	-18.1	-14.9	082	1.6	1.7	082	4.4	E	88	-16.8	****	423	6
7	-11.9	-18.5	-15.2	094	2.1	2.3	120	5.1	ESE	80	-18.1	****	423	7
8	-7.4	-13.6	-10.5	104	1.7	1.8	090	5.7	ESE	82	-11.3	****	340	8
9	-5.7	-8.5	-7.1	194	.1	.5	120	2.5	WSW	13	-38.1	****	310	9
10	-5.9	-13.7	-9.8	088	1.6	1.7	075	4.4	ESE	79	-10.3	****	305	10
11	-3.6	-6.5	-5.1	100	1.3	1.4	117	3.8	ESE	40	-24.3	****	310	11
12	-.5	-6.8	-3.7	130	1.1	1.4	137	4.4	SE	83	-4.3	****	493	12
13	-.7	-6.5	-3.6	121	1.1	1.3	115	4.4	ESE	88	-4.2	****	540	13
14	-3.2	-9.2	-6.2	076	.7	.9	089	3.8	ENE	20	-34.8	****	400	14
15	-6.7	-15.3	-11.0	093	1.6	1.6	095	4.4	E	71	-13.1	****	365	15
16	-13.0	-16.8	-14.9	087	2.0	2.0	088	4.4	E	92	-16.5	****	350	16
17	-15.7	-21.4	-18.6	088	2.3	2.4	097	5.1	E	87	-19.9	****	350	17
18	-15.9	-22.2	-19.1	092	2.2	2.3	090	4.4	E	78	-23.0	****	390	18
19	-15.2	-21.4	-18.3	115	2.8	2.8	115	7.0	ESE	63	-23.2	****	418	19
20	-10.1	-15.3	-12.7	115	2.9	3.0	123	6.3	ESE	79	-15.4	****	330	20
21	-5.8	-10.7	-8.3	093	1.5	1.7	125	4.4	ENE	85	-10.4	****	393	21
22	-4.6	-7.5	-6.1	103	1.6	1.8	119	5.1	ENE	80	-8.9	****	378	22
23	-.8	-6.0	-3.4	112	1.1	1.3	113	3.8	ESE	84	-4.4	****	348	23
24	-1.0	-4.7	-2.9	136	1.4	1.4	138	3.8	SE	91	-3.4	****	335	24
25	.5	-6.7	-3.1	138	1.4	1.5	159	3.8	SE	79	-5.2	****	358	25
26	-4.9	-7.3	-6.1	116	2.4	2.4	110	5.7	ESE	76	-9.7	****	358	26
27	-3.8	-11.8	-7.8	086	1.5	1.6	114	4.4	E	88	-8.5	****	363	27
28	-10.3	-14.7	-12.5	080	2.7	2.7	070	4.4	E	95	-13.8	****	368	28
29	-5.4	-10.1	-7.8	097	1.1	1.2	131	3.8	ENE	31	-15.5	****	258	29
30	-5.8	-12.0	-8.9	259	.4	.7	276	3.8	W	69	-12.2	****	273	30
MONTH	.5	-22.2	-8.9	104	1.4	1.6	113	7.6	ESE	77	-13.6	****	12060	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.1
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 3.8

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING December, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-11.1	-19.9	-15.5	117	.5	.8	280	3.2	SE	92	-17.7	****	268	1
2	-15.1	-21.6	-18.4	121	1.5	1.7	133	5.1	SE	86	-20.1	****	283	2
3	-11.9	-21.4	-16.7	107	1.2	1.6	125	4.4	ESE	80	-18.9	****	293	3
4	-13.1	-18.7	-15.9	108	2.3	2.5	125	6.3	ESE	75	-20.5	****	343	4
5	-4.7	-13.1	-8.9	108	1.3	1.3	098	4.4	ESE	83	-10.3	****	305	5
6	-1.5	-7.5	-4.5	122	1.7	1.9	110	7.0	SE	80	-7.9	****	333	6
7	1.8	-1.9	-.1	107	2.3	2.4	107	9.5	ESE	81	-2.7	****	300	7
8	0.0	-1.8	-.9	134	.7	1.0	305	5.1	SE	11	-36.5	****	258	8
9	-.6	-14.4	-7.5	067	1.0	1.7	277	5.1	ENE	93	-9.1	****	270	9
10	-4.3	-19.1	-11.7	110	1.6	1.9	141	6.3	ESE	96	-13.3	****	273	10
11	-4.8	-8.7	-6.8	129	2.0	2.1	108	6.3	ESE	77	-10.1	****	295	11
12	-2.3	-6.8	-4.6	130	1.5	1.6	124	5.1	ESE	77	-7.2	****	310	12
13	-.1	-5.1	-2.6	145	1.3	1.5	109	6.3	SSE	83	-5.0	****	328	13
14	-.9	-9.0	-5.0	142	1.1	1.2	124	4.4	SE	83	-6.9	****	318	14
15	.3	-5.5	-2.6	130	1.5	1.7	102	5.7	ESE	73	-6.1	****	308	15
16	-.3	-5.0	-2.7	134	1.4	1.5	115	4.4	SE	74	-6.7	****	315	16
17	-2.6	-10.5	-6.6	107	1.8	1.9	117	4.4	ESE	92	-7.5	****	303	17
18	-10.2	-13.9	-12.1	089	1.7	1.8	077	4.4	E	78	-13.0	****	308	18
19	-6.6	-13.0	-9.8	113	1.1	1.3	122	.4	SE	80	-12.3	****	300	19
20	-5.6	-15.3	-10.5	124	1.6	1.8	123	5.1	ESE	74	-13.5	****	315	20
21	-15.0	-18.8	-16.9	083	2.6	2.6	071	5.1	E	91	-17.7	****	310	21
22	-16.0	-20.6	-18.3	075	2.6	2.7	072	5.7	ENE	87	-20.5	****	305	22
23	-11.8	-17.8	-14.8	099	1.8	2.0	101	4.4	ESE	75	-18.1	****	328	23
24	-8.0	-16.8	-12.4	105	2.3	2.5	119	5.7	ESE	80	-14.6	****	308	24
25	-7.8	-12.7	-10.3	102	2.1	2.3	116	6.3	ESE	81	-13.5	****	310	25
26	-.8	-8.7	-4.8	130	1.2	1.4	101	4.4	ESE	80	-8.4	****	300	26
27	.4	-2.9	-1.3	143	.8	1.0	098	3.2	SSE	70	-9.0	****	253	27
28	.9	-.4	.3	145	.3	.4	087	1.9	SE	10	-28.4	****	240	28
29	1.7	-.3	.7	179	.6	1.0	252	3.2	SE	11	-27.5	****	268	29
30	-.1	-9.3	-4.7	***	****	****	***	****	***	5	-37.6	****	253	30
31	-6.6	-10.4	-8.5	***	****	****	***	****	***	1	-46.0	****	250	31
MONTH	1.8	-21.6	-8.2	111	1.4	1.7	107	9.5	ESE	69	-15.7	****	9143	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 7.0
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 6.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 9.5
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 8.9

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING January, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-1.1	-7.2	-4.2	***	****	****	***	****	***	82	-4.8	****	265	1
2	-1.4	-4.2	-2.8	114	2.1	2.1	101	5.1	ESE	78	-8.9	****	268	2
3	-4.2	-11.7	-8.0	115	.9	1.0	107	4.4	ESE	71	-11.4	****	253	3
4	-11.3	-21.0	-16.2	097	1.3	1.5	092	4.4	ENE	87	-18.6	****	278	4
5	-17.9	-24.9	-21.4	102	1.5	1.7	092	4.4	E	79	-25.0	****	278	5
6	-16.3	-21.1	-18.7	112	2.4	2.5	106	8.9	ESE	67	-22.5	****	290	6
7	-17.2	-25.4	-21.3	110	2.5	2.6	094	8.9	ESE	67	-25.4	****	340	7
8	-22.4	-27.0	-24.7	124	1.2	1.5	088	3.1	ESE	66	-29.1	****	363	8
9	-23.2	-26.4	-24.8	133	2.3	2.4	109	5.7	SE	57	-30.4	****	363	9
10	-20.2	-26.2	-23.2	123	2.2	2.3	121	5.7	SE	52	-29.7	****	365	10
11	-18.2	-31.6	-24.9	115	1.7	2.0	140	6.3	E	68	-32.1	****	311	11
12	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	12
13	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	13
14	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	14
15	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	15
16	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	16
17	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	17
18	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	18
19	-5.8	-7.4	-6.6	102	.6	.9	274	2.5	SE	50	-16.8	****	269	19
20	-5.8	-12.3	-9.1	119	1.5	1.6	111	5.1	ESE	82	-10.1	****	358	20
21	-4.4	-11.3	-7.9	128	1.6	1.7	124	4.4	SE	54	-14.4	****	428	21
22	-8.8	-18.0	-13.4	084	2.6	2.6	089	7.0	E	63	-19.2	****	418	22
23	1.6	-15.0	-6.7	120	2.3	2.7	131	8.3	ESE	37	-19.2	****	583	23
24	-3.8	-9.9	-6.9	108	2.3	2.6	100	9.5	ESE	33	-20.5	****	663	24
25	-5.8	-9.9	-7.9	104	2.2	2.3	102	8.3	ESE	42	-18.8	****	550	25
26	-1.9	-7.3	-4.6	115	1.8	2.0	123	7.6	ESE	59	-11.3	****	503	26
27	-5.5	-10.6	-8.1	099	2.2	2.6	113	6.3	ENE	74	-12.3	****	470	27
28	-3.9	-12.2	-8.1	109	1.9	2.1	137	4.4	ESE	61	-10.5	****	530	28
29	-5.4	-13.9	-9.7	091	2.1	2.3	124	5.1	E	81	-11.8	****	490	29
30	-4.0	-9.7	-6.9	121	1.7	1.9	104	6.3	ESE	82	-8.7	****	533	30
31	1.9	-5.3	-1.7	137	1.1	1.3	115	4.4	SE	73	-4.9	****	573	31
MONTH	1.9	-31.6	-12.0	112	1.8	1.5	100	9.5	ESE	65	-17.3	****	9735	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 7.6
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 7.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 5.1

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING February, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	3.3	-1.5	.9	133	1.6	1.7	112	5.7	ESE	67	-4.4	****	595	1
2	1.5	-2.9	-.7	138	1.4	1.6	142	4.4	SE	78	-3.7	****	613	2
3	.3	-3.2	-1.5	135	1.5	1.6	115	7.0	ESE	73	-5.3	****	615	3
4	1.1	-4.0	-1.5	123	1.7	1.8	099	6.3	SE	69	-6.2	****	620	4
5	1.1	-6.7	-2.8	119	1.8	2.0	095	7.6	ESE	64	-7.3	****	703	5
6	1.3	-9.4	-4.1	145	.7	1.2	098	5.7	SSE	79	-5.2	****	625	6
7	-2.4	-7.5	-5.0	251	.3	.8	304	3.8	WSW	38	-22.6	****	495	7
8	-3.8	-12.8	-8.3	122	.2	.6	093	3.8	ESE	56	-14.4	****	448	8
9	-8.9	-18.5	-13.7	117	1.1	1.2	113	4.4	ESE	94	-16.2	****	435	9
10	-8.4	-20.0	-14.2	120	.8	1.1	126	5.1	E	90	-16.0	****	500	10
11	-10.9	-20.2	-15.6	091	1.8	1.9	107	4.4	E	84	-18.7	****	465	11
12	-11.9	-22.8	-17.4	089	1.7	1.8	082	5.1	E	83	-21.5	****	558	12
13	-14.5	-24.2	-19.4	087	2.1	2.4	116	5.1	ENE	78	-22.2	****	583	13
14	-12.5	-19.0	-15.8	068	1.5	1.7	058	4.4	ENE	74	-19.8	****	720	14
15	-5.8	-19.3	-12.6	103	1.9	2.0	123	5.1	ESE	61	-19.2	****	805	15
16	-6.2	-13.7	-10.0	115	2.3	2.4	099	5.1	ESE	47	-20.0	****	843	16
17	-7.4	-15.1	-11.3	128	2.5	2.6	120	6.3	SE	45	-21.9	****	898	17
18	-8.5	-14.7	-11.6	108	2.1	2.2	090	6.3	ESE	68	-16.8	****	628	18
19	-2.2	-13.0	-7.6	108	1.6	1.7	113	4.4	ESE	77	-9.6	****	743	19
20	-1.6	-13.2	-7.4	115	1.5	1.7	089	5.7	SE	70	-10.0	****	1083	20
21	.1	-9.6	-4.8	095	1.5	1.6	096	5.1	E	67	-9.3	****	1040	21
22	3.1	-10.7	-3.8	126	1.4	1.7	114	5.1	SSE	77	-8.2	****	1085	22
23	1.7	-8.8	-3.6	120	1.7	1.9	098	7.0	ESE	58	-10.0	****	1150	23
24	-.8	-7.3	-4.1	109	1.9	1.9	088	5.1	ESE	78	-5.9	****	950	24
25	1.7	-12.7	-5.5	122	1.2	1.6	093	7.6	E	47	-16.5	****	1380	25
26	.5	-4.9	-2.2	125	1.7	1.8	111	6.3	ESE	67	-8.3	****	1363	26
27	1.1	-9.8	-4.4	107	1.5	1.7	118	5.1	ESE	66	-10.0	****	1598	27
28	-1.1	-7.1	-4.1	078	1.1	1.3	109	5.1	NE	58	-15.7	****	1288	28
MONTH	3.3	-24.2	-7.5	112	1.4	1.7	095	7.6	ESE	69	-13.0	****	22838	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 3.8
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 6.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 6.3
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 5.7

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING March, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-2.0	-6.7	-4.4	056	.5	.7	069	2.5	NE	41	-23.3	****	813	1
2	-4.4	-14.1	-9.3	113	1.9	2.0	113	5.7	ESE	70	-11.8	****	1605	2
3	-8.1	-16.5	-12.3	100	2.6	2.8	100	7.0	E	77	-15.8	****	1628	3
4	-9.0	-16.7	-12.9	108	2.6	2.9	097	7.0	E	77	-15.3	****	1275	4
5	-4.4	-12.1	-8.3	099	2.2	2.3	121	5.1	ESE	72	-12.2	****	1093	5
6	-.8	-13.5	-7.2	094	1.8	2.0	096	5.7	E	69	-12.1	****	1765	6
7	-1.0	-10.7	-5.9	096	1.7	2.0	131	5.7	ENE	67	-12.2	****	1828	7
8	.1	-14.3	-7.1	087	2.1	2.3	084	5.1	ENE	58	-15.6	****	2069	8
9	-2.2	-17.1	-9.7	086	2.3	2.5	098	6.3	ENE	55	-18.3	****	2095	9
10	-6.4	-16.3	-11.4	089	1.7	1.8	105	5.1	ENE	80	-12.6	****	1180	10
11	1.5	-7.3	-2.9	103	1.6	1.8	092	5.7	ESE	80	-6.7	****	1625	11
12	6.4	-7.9	-.8	108	1.0	1.3	130	5.1	E	74	-6.9	****	1658	12
13	5.0	-9.2	-2.1	089	1.6	1.9	066	5.1	ENE	67	-8.3	****	2378	13
14	2.6	-7.8	-2.6	094	1.6	1.7	074	5.1	E	67	-7.5	****	2088	14
15	3.4	-5.1	-.9	095	1.5	1.7	099	5.7	E	71	-5.9	****	2123	15
16	3.5	-8.5	-2.5	098	1.7	1.9	097	5.7	ESE	69	-7.4	****	2675	16
17	2.8	-11.8	-4.5	111	1.1	1.4	096	4.4	ESE	67	-8.4	****	2878	17
18	2.6	-11.9	-4.7	101	1.6	1.9	114	5.1	E	75	-9.5	****	2783	18
19	2.1	-13.4	-5.7	087	1.9	2.0	072	5.1	E	71	-10.7	****	2870	19
20	1.4	-7.0	-2.8	090	1.9	1.9	084	6.3	E	64	-8.9	****	2913	20
21	2.7	-7.5	-2.4	095	1.6	1.7	064	5.1	E	56	-10.2	****	3055	21
22	3.2	-10.6	-3.7	093	1.7	1.9	106	5.7	E	59	-11.2	****	3050	22
23	1.3	-11.2	-5.0	100	1.7	1.9	075	5.1	E	59	-11.9	****	3108	23
24	.7	-10.0	-4.7	086	1.6	1.8	060	5.1	E	64	-9.9	****	2575	24
25	2.2	-6.0	-1.9	130	1.4	1.6	117	5.7	ESE	59	-9.3	****	3280	25
26	1.8	-5.7	-2.0	115	2.1	2.4	092	8.3	ESE	54	-10.3	****	3133	26
27	.5	-7.1	-3.3	117	2.1	2.3	108	7.0	ESE	52	-12.0	****	3325	27
28	2.6	-8.0	-2.7	107	1.7	1.8	068	5.7	ESE	55	-11.0	****	3455	28
29	3.3	-11.5	-4.1	094	2.0	2.1	100	6.3	E	67	-9.9	****	3560	29
30	3.4	-11.0	-3.8	104	1.7	2.0	100	5.7	SE	65	-9.8	****	3688	30
31	5.3	-7.4	-1.1	102	1.6	1.9	083	5.1	E	68	-6.6	****	3278	31
MONTH	6.4	-17.1	-4.9	099	1.7	1.9	092	8.3	E	66	-11.0	****	74842	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.1
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 6.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 7.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.6

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING April, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	5.9	-9.0	-1.6	103	1.7	2.0	113	5.7	SE	71	-6.5	0.0	3710	1
2	6.7	-9.2	-1.3	081	1.7	2.1	070	6.3	ENE	64	-6.0	0.0	3963	2
3	5.1	-8.0	-1.5	103	1.9	2.2	109	6.3	ESE	62	-7.3	0.0	4068	3
4	4.6	-2.5	1.1	123	1.3	2.5	281	10.2	ESE	68	-4.6	0.0	1690	4
5	1.6	-3.1	-.8	084	.8	1.2	096	3.8	E	71	-8.1	.2	2505	5
6	3.5	-5.4	-1.0	128	1.0	1.6	127	5.1	SE	52	-14.0	.2	4010	6
7	3.6	-5.4	-.9	121	1.4	1.8	110	4.4	ESE	67	-7.3	0.0	4040	7
8	2.6	-5.9	-1.7	352	.5	1.4	328	4.4	NE	69	-7.6	0.0	2923	8
9	.5	-10.8	-5.2	304	.4	1.3	323	5.1	NW	67	-11.7	.2	2888	9
10	-1.2	-12.3	-6.8	075	1.1	1.7	011	6.3	ESE	58	-12.7	0.0	4403	10
11	-4.5	-12.3	-8.4	096	1.2	1.5	061	6.3	E	68	-13.3	0.0	2380	11
12	3.4	-5.9	-1.3	088	.6	1.0	062	4.4	ESE	50	-14.4	3.4	2445	12
13	3.8	-3.1	.4	105	.9	1.2	102	4.4	ESE	54	-12.5	4.0	3228	13
14	4.4	-2.3	1.1	338	.5	1.4	329	6.3	NW	50	-14.0	.8	3470	14
15	3.4	-1.3	1.1	027	.4	.7	005	3.2	N	29	-22.4	6.0	1970	15
16	5.1	-1.8	1.7	077	.7	1.2	029	7.6	NNE	58	-7.0	3.2	3108	16
17	4.6	-5.2	-.3	115	.0	1.5	251	5.7	W	62	-8.7	0.0	3660	17
18	5.0	-2.7	1.2	073	.9	1.3	054	7.0	ESE	67	-3.6	6.2	3018	18
19	6.1	-1.7	2.2	103	.2	1.6	097	7.0	ESE	61	-6.3	0.0	4625	19
20	6.8	-3.1	1.9	097	1.2	1.6	054	7.6	E	63	-4.7	0.0	4563	20
21	7.6	-3.3	2.2	094	1.4	1.7	100	5.1	ESE	59	-6.7	0.0	5300	21
22	7.2	-.6	3.3	282	.3	1.2	287	3.8	WNW	73	-3.4	.4	3653	22
23	4.3	0.0	2.2	306	.4	.9	323	4.4	WNW	17	-27.5	3.0	2600	23
24	12.1	.9	6.5	083	.5	1.3	047	5.7	ENE	50	-4.3	0.0	5655	24
25	14.3	.5	7.4	152	.7	1.4	099	5.7	S	52	-1.1	0.0	5638	25
26	12.2	-1.6	5.3	245	.4	1.1	317	3.8	SSE	62	-2.0	0.0	5618	26
27	11.1	-2.3	4.4	175	.2	1.3	188	5.1	E	57	-4.2	0.0	5708	27
28	9.4	-1.4	4.0	358	.6	1.4	323	5.1	ENE	59	-8.3	0.0	3845	28
29	6.9	.6	3.8	271	.3	.7	118	3.2	S	56	-10.6	5.6	2908	29
30	10.5	-1.6	4.5	034	1.3	1.8	021	6.3	NNE	41	-7.4	0.0	6235	30
MONTH	14.3	-12.3	.8	090	.6	1.5	281	10.2	ESE	59	-9.0	33.2	113821	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.7
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.1
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.6

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING May, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	11.0	-2.2	4.4	083	.8	1.5	091	5.1	ENE	58	-4.4	.2	5318	1
2	5.1	.3	2.7	304	.5	.9	288	3.8	NW	38	-18.7	6.6	2308	2
3	4.9	-.2	2.4	305	.4	.9	335	3.8	WNW	70	-8.4	2.2	3490	3
4	7.7	-.8	3.5	066	1.3	1.7	023	6.3	ENE	67	-3.3	0.0	4658	4
5	9.4	-.8	4.3	080	.6	1.6	089	6.3	SSW	56	-4.2	0.0	4993	5
6	9.7	-1.5	4.1	057	1.4	2.0	020	7.6	NNE	67	-1.4	0.0	5523	6
7	11.3	-2.1	4.6	035	1.4	1.9	016	6.3	NNE	59	-2.2	0.0	6228	7
8	13.5	-.8	6.4	185	.4	1.5	227	4.4	S	58	-1.4	0.0	6590	8
9	11.9	0.0	6.0	276	.3	1.3	314	5.7	SSW	63	-.3	0.0	5373	9
10	11.1	1.5	6.3	236	.6	1.1	273	5.7	WSW	49	-2.5	0.0	6000	10
11	12.8	-1.2	5.8	219	.4	1.3	307	4.4	SSW	50	-2.1	0.0	6328	11
12	10.7	2.5	6.6	076	1.0	1.6	127	7.0	NNE	59	.5	0.0	4688	12
13	13.2	4.5	8.9	291	.2	1.2	286	3.8	WNW	61	2.1	0.0	4570	13
14	12.9	4.1	8.5	261	.6	1.2	303	4.4	S	67	3.5	0.0	4460	14
15	13.7	2.2	9.0	272	.6	1.2	300	5.1	WNW	66	.2	0.0	4420	15
16	12.7	.3	6.5	070	.4	1.3	056	6.3	E	42	-7.9	2.2	3993	16
17	8.1	2.6	5.4	326	.2	1.3	325	5.1	NW	38	-17.9	4.4	2798	17
18	8.6	2.6	5.6	283	.5	1.4	320	5.7	NW	66	-3.9	.2	4253	18
19	11.4	1.2	6.3	236	.3	1.4	225	5.7	ESE	58	-2.9	.6	5040	19
20	14.5	4.3	9.4	299	1.4	1.9	309	7.0	NW	59	.6	0.0	6095	20
21	10.7	4.3	7.5	294	1.5	1.7	330	6.3	NW	71	-1.6	0.0	3325	21
22	11.3	3.8	7.6	322	.6	1.2	325	5.7	NW	70	.9	1.4	4111	22
23	10.5	3.0	6.8	286	.2	1.1	013	5.1	SW	71	1.0	1.2	4000	23
24	12.4	.9	6.7	077	1.2	1.8	084	6.3	ENE	59	-.7	.2	5280	24
25	15.4	-.9	7.3	294	1.0	1.7	296	7.6	WNW	63	1.9	0.0	5815	25
26	12.7	2.2	7.5	316	.6	1.4	295	6.3	WNW	81	3.8	.2	4008	26
27	12.7	1.1	6.9	049	.6	1.4	002	6.3	ESE	70	3.0	0.0	4323	27
28	16.3	3.4	9.9	036	.4	1.6	100	5.7	S	63	4.8	0.0	5090	28
29	20.1	5.1	12.6	094	1.1	1.6	085	7.0	ENE	57	6.6	0.0	4790	29
30	19.7	8.5	14.1	105	.3	1.5	095	8.9	WSW	65	9.2	0.0	3503	30
31	11.9	6.5	9.2	251	.3	1.0	252	4.4	WNW	90	7.5	6.0	2165	31
MONTH	20.1	-2.2	6.8	004	.2	1.4	095	8.9	WNW	62	-1.2	25.4	143590	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.7
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 6.3
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 2.5

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING September, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	16.6	3.9	10.3	045	.2	.5	186	5.7	NNE	36	-4.3	9.4	3155	1
2	14.7	3.7	9.2	223	.3	.6	220	3.2	SW	27	-7.5	11.6	2835	2
3	11.5	5.0	8.3	043	.2	.4	043	2.5	NE	50	-.6	7.3	1845	3
4	13.8	1.8	7.8	202	.1	.4	187	2.5	SSW	16	-12.9	.2	3073	4
5	16.7	3.1	9.9	050	.9	1.0	047	5.1	NE	20	-9.9	1.0	2255	5
6	15.3	5.2	10.3	186	.5	1.1	135	6.3	SSW	32	-5.7	0.0	1572	6
7	14.3	7.5	10.9	214	.9	.9	213	4.4	SSW	40	-3.7	1.8	2615	7
8	11.9	6.4	9.2	208	.6	.7	208	3.8	SSW	33	-4.6	.2	1878	8
9	12.9	5.6	9.3	202	.0	.3	215	2.5	ESE	**	*****	.8	1718	9
10	12.6	4.8	8.7	037	.1	.3	021	2.5	NE	**	*****	.2	2030	10
11	7.9	-.6	3.7	044	.1	.5	238	5.1	E	51	-3.2	7.6	1190	11
12	11.8	-.4	5.7	048	.4	.5	074	2.5	NE	46	-7.6	3.6	2963	12
13	8.7	4.4	6.6	037	.3	.6	055	2.5	NNE	61	.2	28.6	978	13
14	10.6	7.1	8.9	047	.2	.3	213	1.9	NNE	**	*****	19.0	940	14
15	17.0	7.3	12.2	246	.1	.8	220	5.1	NNE	48	1.6	29.8	2093	15
16	12.1	5.0	8.6	223	1.7	1.9	220	10.2	SW	33	-7.8	11.2	2313	16
17	8.2	2.5	5.4	053	.4	.4	065	3.2	NE	72	-.1	9.4	1198	17
18	12.0	3.7	7.9	033	.3	.5	212	3.2	E	52	-1.4	10.0	1409	18
19	9.4	6.0	7.7	204	.1	.4	224	3.8	SW	62	.9	18.6	775	19
20	9.5	5.5	7.5	153	.0	.3	243	1.9	ENE	53	.1	6.0	1265	20
21	10.0	5.1	7.6	169	.1	.6	217	3.8	NE	**	*****	3.4	1291	21
22	10.2	-.9	4.7	243	.2	.6	214	5.7	WSW	**	*****	5.0	2153	22
23	11.8	-3.3	4.3	054	.5	.6	085	3.2	E	**	*****	.2	3365	23
24	9.9	-5.1	2.4	070	.3	.5	239	3.2	E	**	*****	0.0	2419	24
25	11.1	-3.0	4.1	129	.1	.6	218	3.8	E	**	*****	0.0	2208	25
26	8.1	2.2	5.2	049	.3	.5	093	2.5	ENE	**	*****	19.4	1243	26
27	9.9	-1.4	4.3	058	.2	.7	207	3.2	NNE	**	*****	6.2	1770	27
28	7.3	-3.0	2.2	063	.5	.5	103	1.9	NE	**	*****	5.4	1340	28
29	9.4	2.6	6.0	074	.3	.9	208	4.4	ENE	**	*****	7.4	1605	29
30	7.2	2.5	4.9	215	1.0	1.1	198	5.1	SSW	**	*****	8.4	1785	30
MONTH	17.0	-5.1	7.1	163	.1	.6	220	10.2	ENE	35	-3.9	232.2	57356	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.7
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 8.9

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING October, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	4.5	-.1	2.2	059	.2	.4	210	2.5	ENE	**	*****	****	1300	1
2	7.6	-1.0	3.3	064	.3	.4	349	2.5	ESE	**	*****	****	2080	2
3	7.4	-1.8	2.8	067	.9	.7	050	4.4	ENE	**	*****	****	2350	3
4	7.8	-5.2	1.3	073	.8	.8	096	3.8	ENE	**	*****	****	2733	4
5	6.1	-5.9	.1	063	1.6	1.7	047	7.6	NE	**	*****	****	2750	5
6	5.6	-1.1	2.3	060	1.4	1.5	075	6.3	ENE	**	*****	****	1920	6
7	1.8	-.8	.5	061	.8	1.0	062	4.4	ENE	**	*****	****	755	7
8	1.8	-1.6	.1	048	.4	1.0	027	3.2	ENE	**	*****	****	855	8
9	2.4	-2.2	.1	216	1.1	.8	212	3.8	SSW	**	*****	****	763	9
10	-.4	-3.5	-2.0	214	2.3	1.2	219	5.1	SSW	**	*****	****	1020	10
11	2.0	-3.3	-.7	060	1.1	1.1	043	5.7	ENE	**	*****	****	765	11
12	2.0	.1	1.1	060	.4	.4	047	1.9	NE	**	*****	****	538	12
13	.5	-5.2	-2.4	031	.4	.6	214	3.2	NE	**	*****	****	345	13
14	1.3	-11.5	-5.1	079	1.0	.7	072	3.8	E	**	*****	****	623	14
15	1.2	-14.3	-6.6	040	.7	.6	028	2.5	E	**	*****	****	1500	15
16	-.8	-7.5	-4.2	***	****	.7	***	****	***	**	*****	****	293	16
17	5.0	-8.4	-1.7	026	.3	.4	026	1.9	NNE	**	*****	****	835.	17
18	2.4	-11.0	-4.3	153	.1	.4	046	1.9	S	**	*****	****	1540	18
19	.8	-4.2	-1.7	***	****	.3	***	****	***	**	*****	****	243	19
20	.7	-13.8	-6.6	***	****	.6	***	****	***	**	*****	****	630	20
21	-2.8	-12.8	-7.8	067	2.3	2.2	084	7.6	ENE	**	*****	****	893	21
22	-1.5	-10.6	-6.1	058	2.1	2.3	057	7.0	NE	**	*****	****	1485	22
23	-2.0	-15.5	-8.0	080	1.5	1.6	055	6.3	E	**	*****	****	1240	23
24	-3.4	-19.4	-11.4	076	.6	.7	081	3.8	E	**	*****	****	1323	24
25	-4.3	-21.5	-12.9	096	.2	.4	124	1.3	E	**	*****	****	1193	25
26	-20.8	-24.6	-22.7	079	.5	.5	077	2.5	ENE	**	*****	****	153	26
27	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	27
28	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	28
29	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	29
30	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	30
31	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	31
MONTH	7.8	-24.6	-3.5	068	.8	.5	047	7.6	ENE	**	*****	****	30135	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.1
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.1
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 5.1

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING November, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	1
2	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	2
3	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	3
4	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	4
5	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	5
6	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	6
7	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	7
8	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	8
9	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	9
10	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	10
11	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	11
12	0.0	-3.1	-1.6	080	.9	.7	078	3.2	E	25	-19.7	****	178	12
13	-2.1	-7.1	-4.6	035	.2	.3	352	1.9	ENE	44	-14.3	****	278	13
14	-1.8	-10.6	-6.2	***	****	.2	***	****	***	**	*****	****	233	14
15	-10.1	-16.9	-13.5	092	.1	.2	092	1.3	E	**	*****	****	171	15
16	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	16
17	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	17
18	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	18
19	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	19
20	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	20
21	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	21
22	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	22
23	0.0	-3.2	-1.6	038	.6	.6	061	3.8	NNE	33	-15.0	****	275	23
24	-.5	-10.7	-5.6	073	.5	.5	053	1.3	ENE	**	*****	****	268	24
25	.8	-10.9	-5.1	056	.7	.8	091	3.2	ENE	26	-22.4	****	273	25
26	-5.3	-10.5	-7.9	048	.9	.9	044	3.2	NE	34	-25.2	****	270	26
27	-7.5	-16.5	-12.0	075	.6	.6	073	1.9	ENE	30	-20.9	****	245	27
28	-14.6	-20.1	-17.4	068	.3	.3	080	1.9	ENE	22	-33.3	****	260	28
29	-4.9	-14.3	-9.6	***	****	0.0	079	.6	***	37	-21.9	****	190	29
30	-7.8	-13.0	-10.4	***	****	.0	***	****	***	28	-26.8	****	160	30
MONTH	.8	-20.1	-7.9	059	.6	.4	061	3.8	ENE	32	-22.1	****	2799	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 1.3
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 1.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 1.3
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 1.3

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING December, 1982

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-12.1	-18.0	-15.1	071	.7	.6	106	3.2	NE	**	*****	****	203	1
2	-16.8	-21.9	-19.4	047	1.2	1.3	029	4.4	NNE	**	*****	****	220	2
3	-14.5	-24.5	-19.5	064	1.0	1.0	030	3.2	ENE	**	*****	****	227	3
4	-13.4	-18.2	-15.8	044	1.2	1.2	050	3.8	NE	**	*****	****	303	4
5	-2.3	-14.0	-8.2	057	1.5	1.6	083	4.4	NE	**	*****	****	275	5
6	.4	-9.2	-4.4	055	1.4	1.5	063	5.1	ENE	**	*****	****	283	6
7	4.0	-1.1	1.5	056	1.4	1.4	046	6.3	NE	**	*****	****	243	7
8	.9	-.4	.3	***	0.0	0.0	***	0.0	***	**	*****	****	200	8
9	1.3	-15.8	-7.3	101	.2	.8	178	6.3	E	**	*****	****	203	9
10	-5.1	-19.4	-12.3	087	.7	.7	111	3.2	E	**	*****	****	258	10
11	-2.4	-8.7	-5.6	064	1.5	1.6	030	3.8	ENE	**	*****	****	230	11
12	.4	-5.7	-2.7	059	1.4	1.5	042	4.4	ENE	**	*****	****	270	12
13	1.1	-7.6	-3.3	063	.8	.9	052	3.2	ENE	**	*****	****	240	13
14	-.2	-8.9	-4.6	043	1.0	1.2	335	4.4	ENE	**	*****	****	258	14
15	2.2	-8.7	-3.3	063	1.2	1.3	065	3.8	ENE	**	*****	****	240	15
16	-.3	-8.9	-4.6	048	.9	1.0	029	3.2	NE	**	*****	****	238	16
17	-2.8	-14.1	-8.5	062	.4	.4	086	1.9	ENE	**	*****	****	230	17
18	-13.4	-18.9	-16.2	055	.3	.4	075	1.9	ENE	**	*****	****	255	18
19	-4.5	-21.1	-12.8	039	.9	1.0	052	4.4	NNE	**	*****	****	228	19
20	-6.3	-16.4	-11.4	056	.9	1.0	012	3.8	ENE	**	*****	****	263	20
21	-14.9	-22.7	-18.8	082	.8	.8	088	1.9	E	**	*****	****	240	21
22	-19.9	-26.6	-23.3	072	.6	.7	090	2.5	ENE	**	*****	****	248	22
23	-11.2	-22.1	-16.7	054	.8	.8	031	2.5	ENE	**	*****	****	258	23
24	-8.0	-19.4	-13.7	069	.8	.9	056	2.5	ENE	**	*****	****	228	24
25	-8.4	-17.5	-13.0	060	.7	.8	020	2.5	ENE	**	*****	****	203	25
26	-1.4	-7.5	-4.5	055	1.1	1.2	061	3.8	ENE	**	*****	****	248	26
27	.1	-4.3	-2.1	068	.4	.4	082	1.9	ENE	**	*****	****	170	27
28	.4	.1	.3	063	.4	.2	092	1.9	NE	**	*****	****	173	28
29	.9	.1	.5	092	.2	.4	102	3.2	NE	**	*****	****	173	29
30	1.5	-5.6	-2.1	221	.5	.6	226	2.5	SW	**	*****	****	223	30
31	-2.5	-6.7	-4.6	***	****	****	***	****	***	**	*****	****	165	31
MONTH	4.0	-26.6	-8.7	059	.9	.9	046	6.3	ENE	**	*****	****	7187	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.7
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.1
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 4.4
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 3.2

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING January, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-.9	-5.0	-3.0	***	****	****	***	****	***	**	*****	****	206	1
2	0.0	-5.8	-2.9	***	****	****	***	****	***	**	*****	****	220	2
3	-3.9	-7.1	-5.5	***	****	****	***	****	***	**	*****	****	188	3
4	-6.9	-20.8	-13.9	***	****	****	***	****	***	**	*****	****	268	4
5	-18.0	-25.8	-21.9	***	****	****	***	****	***	**	*****	****	278	5
6	-14.3	-20.0	-17.2	061	3.4	3.1	062	7.6	ENE	**	*****	****	330	6
7	-16.3	-29.5	-22.9	058	2.0	2.1	051	7.0	ENE	**	*****	****	323	7
8	-16.8	-32.2	-24.5	060	1.8	1.5	052	6.9	NE	**	*****	****	358	8
9	-20.5	-27.0	-23.8	035	1.2	1.3	046	3.6	NNE	**	*****	****	355	9
10	-17.7	-27.8	-22.8	054	.9	1.2	053	5.7	NE	**	*****	****	348	10
11	-11.9	-25.9	-18.9	062	4.2	4.4	069	12.1	ENE	**	*****	****	528	11
12	-14.2	-17.6	-15.9	068	2.4	2.5	056	8.9	ENE	**	*****	****	438	12
13	-14.3	-17.9	-16.1	068	2.1	2.2	077	7.6	ENE	**	*****	****	393	13
14	-7.9	-20.7	-14.3	050	1.1	1.2	071	4.4	ENE	**	*****	****	405	14
15	1.6	-13.5	-6.0	047	1.7	1.8	070	5.7	ENE	**	*****	****	345	15
16	.7	-5.0	-2.2	043	.8	.9	054	5.1	NE	**	*****	****	333	16
17	-3.4	-13.4	-8.4	062	.3	.6	215	2.5	ENE	**	*****	****	228	17
18	2.3	-9.4	-3.6	066	1.3	1.4	065	7.0	ENE	**	*****	****	275	18
19	0.0	-6.2	-3.1	070	.2	.6	227	5.7	ENE	**	*****	****	171	19
20	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	20
21	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	21
22	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	22
23	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	23
24	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	24
25	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	25
26	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	26
27	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	27
28	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	28
29	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	29
30	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	30
31	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	31
MONTH	2.3	-32.2	-13.6	059	1.6	1.8	069	12.1	ENE	**	*****	****	5998	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 8.3
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 10.2
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING February, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	1
2	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	2
3	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	3
4	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	4
5	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	5
6	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	6
7	-.1	-8.3	-4.2	089	.4	.6	073	2.5	E	##	#####	####	652	7
8	-1.9	-13.6	-7.8	072	.2	.3	047	3.2	E	##	#####	####	733	8
9	-9.0	-21.9	-15.5	076	.5	.6	045	2.5	E	##	#####	####	1135	9
10	-7.5	-23.3	-15.4	078	.4	.5	095	3.2	ENE	##	#####	####	1118	10
11	-10.1	-26.1	-18.1	059	.5	.6	044	2.5	NE	##	#####	####	1215	11
12	-10.5	-28.0	-19.3	060	.3	.5	141	1.9	ENE	##	#####	####	1305	12
13	-24.7	-29.6	-27.2	043	.4	.4	027	1.3	ENE	##	#####	####	398	13
14	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	14
15	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	15
16	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	16
17	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	17
18	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	18
19	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	19
20	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	20
21	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	21
22	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	22
23	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	23
24	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	24
25	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	25
26	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	26
27	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	27
28	#####	#####	#####	###	####	####	###	####	###	##	#####	####	######	28
MONTH	-.1	-29.6	-15.3	069	.4	.5	047	3.2	ENE	##	#####	####	6555	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 1.3
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 1.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 2.5
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 1.9

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING March, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	1
2	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	2
3	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	3
4	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	4
5	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	5
6	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	6
7	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	7
8	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	8
9	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	9
10	-2.6	-15.1	-8.9	061	1.2	1.3	074	4.4	ENE	**	*****	****	2556	10
11	4.4	-7.8	-1.7	056	1.0	1.0	053	3.8	ENE	**	*****	****	1913	11
12	8.6	-8.3	.2	063	1.0	1.2	062	4.4	ENE	**	*****	****	1980	12
13	8.6	-10.5	-1.0	068	.9	1.0	076	4.4	ENE	**	*****	****	2790	13
14	5.3	-11.2	-3.0	069	.9	.9	075	3.8	ENE	**	*****	****	2270	14
15	8.5	-8.5	0.0	065	.5	.7	010	3.8	E	**	*****	****	2460	15
16	6.8	-10.4	-1.8	068	.8	.9	076	4.4	ENE	**	*****	****	3080	16
17	6.4	-13.9	-3.8	076	.8	.8	084	4.4	ENE	**	*****	****	3255	17
18	6.0	-15.7	-4.9	069	.9	1.0	069	5.1	E	**	*****	****	3355	18
19	5.9	-15.8	-5.0	073	.8	.9	078	4.4	E	**	*****	****	3423	19
20	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	20
21	7.1	-10.3	-1.6	069	1.1	1.1	072	4.4	ENE	**	*****	****	3423	21
22	7.1	-15.0	-4.0	075	.6	.7	085	3.8	ENE	**	*****	****	3520	22
23	5.9	-14.8	-4.5	068	.7	.8	079	4.4	ENE	**	*****	****	3610	23
24	4.7	-11.9	-3.6	052	.8	.9	067	3.8	ENE	**	*****	****	2533	24
25	5.2	-8.0	-1.4	063	1.4	1.5	081	5.7	ENE	**	*****	****	3695	25
26	5.1	-8.3	-1.6	050	2.0	2.0	049	7.6	NE	**	*****	****	3435	26
27	4.3	-7.9	-1.8	059	1.9	1.9	052	7.0	ENE	**	*****	****	3663	27
28	5.8	-9.9	-2.1	065	1.4	1.5	077	5.1	ENE	**	*****	****	3790	28
29	7.6	-11.7	-2.1	077	1.1	1.1	071	4.4	E	**	*****	****	3950	29
30	6.5	-12.1	-2.8	072	1.2	1.2	077	5.1	ENE	**	*****	****	4220	30
31	10.0	-8.0	1.0	065	.7	.8	055	3.8	ENE	**	*****	****	3553	31
MONTH	10.0	-15.8	-2.6	065	1.0	1.1	049	7.6	ENE	**	*****	****	66524	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.7
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 6.3
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 6.3

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

SUSITNA

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING April, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	9.2	-10.1	-.5	070	1.0	1.1	082	4.4	E	**	*****	0.0	4243	1
2	9.6	-8.8	.4	069	1.0	1.1	082	5.7	ENE	**	*****	0.0	4435	2
3	8.3	-10.7	-1.2	063	1.2	1.2	065	4.4	ENE	**	*****	0.0	4500	3
4	7.6	-.5	3.6	135	.2	1.9	212	10.2	NE	**	*****	2.2	1903	4
5	5.1	-2.4	1.4	053	.2	.6	352	3.2	ENE	**	*****	2.6	2065	5
6	2.6	-11.3	-4.4	096	.8	1.1	120	4.4	E	**	*****	2.2	4948	6
7	7.5	-4.5	1.5	104	.1	.2	064	2.5	ENE	**	*****	0.0	4528	7
8	4.4	-5.4	-.5	235	.8	.8	223	4.4	SW	**	*****	0.0	3908	8
9	3.7	-9.5	-2.9	217	.8	1.0	208	3.8	SSW	**	*****	.6	3155	9
10	2.6	-11.3	-4.4	096	.8	1.1	120	4.4	E	**	*****	0.0	4948	10
11	-1.9	-11.7	-6.8	057	1.3	1.4	035	5.1	ENE	**	*****	0.0	2727	11
12	3.4	-4.3	-.5	039	.1	.7	030	3.2	NNE	**	*****	8.4	2070	12
13	7.4	-3.8	1.8	084	.7	.6	046	3.2	E	**	*****	4.0	4438	13
14	5.1	-.9	2.1	220	.8	.9	229	4.4	SW	**	*****	5.0	2715	14
15	4.5	0.0	2.3	041	.3	.5	211	2.5	NNE	**	*****	14.2	2175	15
16	7.6	-1.7	3.0	066	1.3	1.1	059	5.1	ENE	**	*****	1.8	3900	16
17	5.1	-5.3	-.1	218	.9	1.2	231	5.1	SSW	**	*****	.2	4218	17
18	7.0	-1.3	2.9	052	.6	.8	020	5.1	ENE	**	*****	11.0	3580	18
19	7.5	-3.3	2.1	210	.5	1.2	206	4.4	SSW	**	*****	0.0	3908	19
20	9.9	-4.3	2.8	071	.9	1.1	077	5.1	E	**	*****	0.0	5030	20
21	10.1	-4.5	2.8	093	.6	.8	031	3.8	ENE	**	*****	0.0	5143	21
22	8.8	-2.2	3.3	214	.2	.5	169	4.4	S	**	*****	3.4	3503	22
23	7.6	.5	4.1	200	.1	.5	212	3.2	SW	**	*****	6.4	3140	23
24	15.1	.1	7.6	023	.5	.9	001	4.4	ENE	**	*****	0.0	6030	24
25	19.4	-1.6	8.9	183	.3	.7	196	3.8	E	**	*****	0.0	6008	25
26	14.3	-3.7	5.3	315	.3	.6	305	3.2	WNW	**	*****	0.0	6028	26
27	14.8	-3.7	5.6	225	.1	.7	166	3.2	NE	**	*****	0.0	6113	27
28	10.5	-2.9	3.8	215	.6	.8	212	5.1	SSW	**	*****	0.0	4195	28
29	10.6	.1	5.4	156	.1	.4	200	2.5	ENE	**	*****	6.0	4245	29
30	13.7	-2.0	5.9	042	1.0	1.2	007	5.1	ENE	**	*****	0.0	6580	30
MONTH	19.4	-11.7	1.8	084	.3	.9	212	10.2	ENE	**	*****	68.0	124380	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 9.5
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 8.9
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING May, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	14.4	-3.7	5.4	127	.3	.8	204	4.4	ENE	**	*****	.6	5418	1
2	8.2	1.1	4.7	219	1.1	1.2	216	5.1	SW	**	*****	5.0	4123	2
3	8.8	-.1	4.4	208	1.1	1.3	214	4.4	SSW	**	*****	.8	4618	3
4	11.9	-1.6	5.2	056	.7	1.1	028	5.1	ENE	**	*****	0.0	5820	4
5	12.3	-.8	5.8	043	.5	1.0	347	5.7	E	**	*****	0.0	6433	5
6	14.3	-2.2	6.1	058	.8	.9	350	5.7	ENE	**	*****	0.0	7015	6
7	15.4	-2.2	6.6	040	.6	.9	347	5.1	E	**	*****	0.0	6853	7
8	16.9	-2.5	7.2	308	.2	.8	213	3.8	NE	**	*****	0.0	6955	8
9	15.0	-.5	7.3	244	.4	.8	263	4.4	SSW	**	*****	0.0	5903	9
10	14.0	-.8	6.6	233	.5	.9	293	5.1	SW	**	*****	0.0	6283	10
11	16.8	-.8	8.0	341	.2	.8	316	3.8	ESE	**	*****	0.0	6765	11
12	14.5	2.2	8.4	127	.4	.7	136	3.8	ESE	**	*****	0.0	5783	12
13	16.4	2.4	9.4	001	.2	.8	017	3.8	ESE	**	*****	0.0	5783	13
14	16.1	.9	8.5	223	.5	1.0	195	5.7	SSW	**	*****	.2	4833	14
15	14.2	.3	7.3	237	.3	.8	234	3.8	E	**	*****	0.0	4793	15
16	13.6	-.3	6.7	238	.6	1.0	218	5.1	WSW	**	*****	1.0	4183	16
17	10.8	3.1	7.0	222	.8	1.0	184	7.0	SW	**	*****	7.0	3528	17
18	11.4	2.7	7.1	222	1.1	1.3	225	6.3	SW	**	*****	.6	4838	18
19	12.7	1.6	7.2	216	.5	.9	199	4.4	SW	**	*****	0.0	4285	19
20	18.2	1.8	10.0	237	1.3	1.5	234	6.3	WSW	**	*****	0.0	6615	20
21	11.1	4.6	7.9	216	1.3	1.4	253	6.3	SSW	**	*****	1.4	3365	21
22	14.5	5.1	9.8	227	.9	1.2	272	5.7	SSW	**	*****	2.0	5068	22
23	14.4	4.1	9.3	206	.9	1.2	227	5.1	SSW	**	*****	.4	4973	23
24	16.4	-.1	8.2	078	.6	1.0	090	5.1	SE	**	*****	0.0	5889	24
25	1.8	-2.2	-.2	105	.2	.2	145	.6	ESE	**	*****	.4	960	25
26	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	26
27	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	27
28	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	28
29	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	29
30	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	30
31	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	31
MONTH	18.2	-3.7	6.9	217	.3	.1	184	7.0	SSW	**	*****	19.4	131075	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 3.8
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 3.2
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 3.2

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

SEP 1982 26528
TALKEETNA, ALASKA
TALKEETNA AIRPORT

ISSN 0198-0424

LOCAL CLIMATOLOGICAL DATA

Monthly Summary

WEA SVC CONTRACT MET OBSY

LATITUDE 62° 18' N LONGITUDE 150° 06' W ELEVATION (GROUND) 345 FEET TIME ZONE ALASKAN WBAN #26528

SEP 1982
TALKEETNA, ALASKA

DATE	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65°F: HEATING (SEASON BEGINS WITH JUL)	COOLING (SEASON BEGINS WITH JAN)	WEATHER TYPES (1 FOG, 2 HEAVY FOG, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW)	SNOW ICE PELLETS OR ICE ON GROUND AT 08AM INCHES	PRECIPITATION: WATER EQUIVALENT (INCHES)	SNOW, ICE PELLETS (INCHES)	AVERAGE STATION PRESSURE IN INCHES ELEV. 356 FEET ABOVE M.S.L.	WIND (M.P.H.): RESULTANT DIR.	RESULTANT SPEED	AVERAGE SPEED	FASTEST MILE: SPEED	DIRECTION	SUNSHINE: MINUTES	PERCENT OF TOTAL POSSIBLE	SKY COVER (TENTHS): SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	62	45	54	3	46	11	0		0	0	0	29.43	31	6	3.5	6	02					1
2	59	43	51	0	48	14	0		0	.37	0	29.56	28	.5	3.9	8	13					2
3	53	45	49	-2	47	16	0		0	.43	0	29.68	01	2.[illegible]	3.7	8	36			10	10	3
4	59	41	50	0	44	15	0		0	0	0	29.54	01	2.0	2.9	8	03			9	8	4
5	57	41	49	-1	46	16	0		0	03	0	28.99	0	5.7	5.8	9	01			10	10	5
6	55	43	49	-1	47	16	0		0	.01	0	28.75	17	3.6	5.8	12	17					6
7	60	47	54	5		11	0		0	.15	0					9	17					7
8	56	44	50	1	46	15	0		0	T	0	29.22	17	3.5	4.3	10	17					9
9	56	43	50	1	47	15	0		0	.19	0	29.25	35	1.5	3.6	8	33					9
10	55	45	50	2	46	15	0		0	.05	0	29.33	34	3.1	4.2	8	32			10	10	10
11	49	38	44	-4	44	21	0	1	0	.22	0	29.46	16	7.1	7.2	15	16			9	7	11
12	52	29	41	-7	37	24	0		0	.12	0	29.70	34	1.7	3.0	6	02			7	7	12
13	49	42	46	-1	45	19	0	1	0	1.25	0	29.47	36	2.7	4.6	12	35					13
14	52	44	48	1		17	0		0	.56	0					9	36					14
15	63*	46	55*	8	51	10	0		0	1.11	0	29.34	01	3.5	4.8	12	36					15
16	56	44	50	4	42	15	0		0	.46	0	29.48	19	7.8	9.0	18	18					16
17	49	41	45	-1	43	20	0		0	.10	0	29.62	36	4.3	4.5	7	02			10	10	17
18	52	41	47	2	44	18	0		0	.50	0	29.41	02	4.9	5.2	16	01			10	10	18
19	49	45	47	2	47	18	0	1	0	.71	0	29.37	03	1.1	2.2	7	03			10	10	19
20	49	44	47	2	46	18	0		0	.16	0	29.52	01	3.3	4.3	10	34					20
21	50	41	46	2		19	0	1	0	.22	0					12	09					21
22	49	32	41	-3	40	24	0		0	.03	0	29.62	04	2.3	3.5	8	25					22
23	52	29	41	-2	32	24	0		0	0	0	29.73	33	1.3	4.3	8	26					23
24	48	26*	37	-6	32	28	0		0	0	0	29.64	28	1.6	3.3	6	13			9	9	24
25	48	30	39	-3	35	26	0		0	0	0	29.46	11	.5	2.0	5	33			9	8	25
26	48	39	44	2	42	21	0	1	0	.40	0	29.42	12	1.8	5.2	10	15			10	10	26
27	53	31	42	1	39	23	0		0	.01	0	29.75	27	1.9	3.8	12	16			9		27
28	45	29	37*	-4		28	0	1	0	.15	0					8	33			10		28
29	49	38	44	3	39	21	0	1	0	.19	0	29.24	34	1.1	5.3	8	18			10		29
30	47	37	42	2	39	23	0	1	0	.12	0	29.21	17	.6	1.6	6	28			10		30
	SUM 1581	SUM 1183				TOTAL 561	TOTAL 0	NUMBER OF DAYS		TOTAL 7.54	TOTAL 0	FOR THE MONTH:				18	18	TOTAL	% FOR MONTH	SUM	SUM	
	AVG. 52.7	AVG. 39.4	AVG. 46.1	DEP. 0.0	AVG.	DEP. -6	DEP. 0	PRECIPITATION > .01 INCH	24	DEP. 3.02						DATE: 16		POSSIBLE		AVG.	AVG.	

NUMBER OF DAYS				SEASON TO DATE				GREATEST IN 24 HOURS AND DATES			GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	SNOW, ICE PELLETS > 1.0 INCH	0	PRECIPITATION		SNOW, ICE PELLETS	
≥ 90°	≤ 32°	≤ 32°	≤ 0°	1097	1	THUNDERSTORMS	0				
0	0	7	0	DEP. -12	DEP. -5	HEAVY FOG	0	1.27	12-13	0	0
						CLEAR PARTLY CLOUDY CLOUDY					

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
+ ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
BLANK ENTRIES DENOTE MISSING DATA.
HOURS OF OPS. MAY BE REDUCED ON A VARIABLE SCHEDULE.

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I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC CENTER, ASHEVILLE, NORTH CAROLINA, 28801.

L. Ray Hoxit
ACTING DIRECTOR
NATIONAL CLIMATIC CENTER

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE / NATIONAL CLIMATIC CENTER ASHEVILLE, NORTH CAROLINA

OCT 1982 TALKEETNA, ALASKA

OCT 1982 26528
TALKEETNA, ALASKA
TALKEETNA AIRPORT

ISSN 0198-0424

LOCAL CLIMATOLOGICAL DATA

Monthly Summary

WEA SVC CONTRACT MET OBSY

LATITUDE 62° 18' N LONGITUDE 150° 06' W ELEVATION (GROUND) 345 FEET TIME ZONE ALASKAN WBAN #26528

DATE 1	TEMPERATURE °F: MAXIMUM 2	MINIMUM 3	AVERAGE 4	DEPARTURE FROM NORMAL 5	AVERAGE DEW POINT 6	DEGREE DAYS BASE 65°F: HEATING (SEASON BEGINS WITH JUL) 7A	COOLING (SEASON BEGINS WITH JAN) 7B	WEATHER TYPES (1 FOG, 2 HEAVY FOG, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW) 8	SNOW ICE PELLETS OR ICE ON GROUND AT 08AM INCHES 9	PRECIPITATION: WATER EQUIVALENT (INCHES) 10	SNOW, ICE PELLETS (INCHES) 11	AVERAGE STATION PRESSURE IN INCHES ELEV 356 FEET ABOVE M.S.L. 12	WIND (M.P.H.): RESULTANT DIR 13	RESULTANT SPEED 14	AVERAGE SPEED 15	FASTEST MILE: SPEED 16	DIRECTION 17	SUNSHINE: MINUTES 18	PERCENT OF TOTAL POSSIBLE 19	SKY COVER (TENTHS): SUNRISE TO SUNSET 20	MIDNIGHT TO MIDNIGHT 21	DATE 22
1	43	35	39	-1	39	26	0	1	0	0	0	29.41	15	1.0	2.6	9	14			10	10	1
2	45	34	40*	1	37	25	0		0	02	0	29.34	35	1.0	1.9	7	01			10	10	2
3	44	28	36	-3	34	29	0		0	04	0	29.21	36	1.9	3.0	8	19			9	8	3
4	45*	24	35	-3	29	30	0		0	0	0	29.14	11	.4	3.3	8	24					4
5	44	21	33	-5		32	0		0	0	0					17	03			0		5
6	43	30	37	0	23	28	0		0	0	0	28.81	07	1.6	6.1	17	03			10		6
7	34	28	31	-6	30	34	0	1	0	42	7.1	29.02	18	1.4	1.6	10	09			10		7
8	35	30	33	-3	30	32	0	1	8	10	2.6	29.29	02	2.5	6.8	12	36			10	10	8
9	34	30	32	-4	31	33	0	1	9	02	.6	29.19	16	1.4	1.6	7	32			10	10	9
10	32	26	29	-6	26	36	0	1	8	T	T	29.41	15	2.9	3.9	12	16			10	10	10
11	36	26	31	-4	26	34	0		8	.01	.1	29.19	36	8.1	9.7	17	02					11
12	39	31	35	1		30	0	1	6	.15	T					9	35			10		12
13	33	23	28	-6	27	37	0	1	4	.34	3.8	29.66	15	4.3	5.1	12	16			10		13
14	32	20	26	-7	25	39	0		5	T	T	29.97	35	2.9	3.6	13	35			10		14
15	30	10	20	-13	18	45	0	2	5	0	0	30.06	34	.8	1.3	5	19			2	5	15
16	31	22	27	-5	26	38	0	1	5	.24	4.0	29.73	36	6.3	7.3	14	02			10	10	16
17	36	18	27	-5	29	38	0	2	8	.01	0	29.81	10	.4	.9	6	34			7	5	17
18	28	12	20	-11	22	45	0	1	8	0	0	30.02	26	.9	2.3	6	26					18
19	33	21	27	-4		38	0	1	10	.33	3.1					6	28			10		19
20	33	22	28	-2	21	37	0	2	11	0	0	29.61	36	5.3	6.2	13	33			7		20
21	28	20	24	-6	8	41	0		11	0	0	29.20	36	11.6	13.6	23	01			7		21
22	31	10	21	-8	8	44	0		10	0	0	28.96	36	10.1	10.5	21	36			6	3	22
23	26	5	16	-12	7	49	0		10	0	0	29.04	34	6.0	7.1	12	32			0	0	23
24	21	-1	10	-18	2	55	0		10	0	0	29.10	01	2.3	3.5	7	01			4	3	24
25	23	-5	9	-18	1	56	0		10	0	0	29.10	02	1.8	3.1	6	29					25
26	18	-10	4	-23		61	0		10	0	0					12	32			0	0	26
27	15	-12	2	-24	-5	63	0		10	T	T	29.53	36	3.6	5.1	10	35			3		27
28	16	9	13	-13	9	52	0	1	10	39	7.2	28.98	36	6.0	7.1	14	02			10		28
29	22	-10	6	-19	5	59	0		16	T	T	28.99	02	1.5	2.2	5	05			1	3	29
30	10	-16*	-3*	-28	-10	68	0		16	0	0	29.19	04	1.6	2.6	6	29			0	1	30
31	20	-15	3	-21	-3	62	0		16	0	0	29.47	01	8.2	8.5	16	02			9	7	31
	SUM 960	SUM 466				TOTAL 1296	TOTAL 0	NUMBER OF DAYS		TOTAL 2.07	TOTAL 28.5	FOR THE MONTH:				23	01	TOTAL	% FOR MONTH	SUM	SUM	
	AVG. 31.0	AVG. 15.0	AVG. 23.0	DEP. -9.1	AVG.	DEP. 276	DEP. 0	PRECIPITATION > .01 INCH.	12	DEP. -0.47						DATE: 21		POSSIBLE		AVG.	AVG.	

NUMBER OF DAYS: MAXIMUM TEMP. ≥ 90°	MAXIMUM TEMP. ≤ 32°	MINIMUM TEMP. ≤ 32°	MINIMUM TEMP. ≤ 0°	SEASON TO DATE TOTAL	TOTAL
				2393	1
				DEP.	DEP.
0	16	29	7	264	-5

NUMBER OF DAYS	
SNOW, ICE PELLETS ≥ 1.0 INCH	6
THUNDERSTORMS	0
HEAVY FOG	3
CLEAR	
PARTLY CLOUDY	
CLOUDY	

GREATEST IN 24 HOURS AND DATES: PRECIPITATION	DATES	SNOW, ICE PELLETS	DATES	GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	DATE
.46	7- 8	8.3	7- 8	16	31+

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1	31	19	25	1	22	40	0		15	.12	2.1	29.29	01	8.7	9.6	16	01			10		1
2	33	14	24	1		41	0	1	16	.02	4					6	28			10		2
3	21	7	14	-9	11	51	0		15	0	0	28.76	05	1.8	3.7	9	21			9		3
4	22	8	15	-7	12	50	0		14	T	T	28.80	33	.4	.4	4	33			10		4
5	23	4	14	-8	11	51	0	1	14	.03	.3	29.24	00	.0	.0	5	01			10	9	5
6	13	-8	3	-18	0	62	0		14	0	0	29.51	01	1.4	1.4	5	04			2	3	6
7	14	-11	2	-19	-6	63	0		14	0	0	29.57	02	3.8	4.2	13	35			0	1	7
8	21	14	18	-3	15	47	0	1	14	29	4.4	29.28	01	7.0	9.6	16	36			10		8
9	26	18	22	2		43	0		17	0	0					9	02			10		9
10	27	18	23	3	17	42	0	1	17	.06	1.8	29.73	03	8.5	8.9	17	01			10		10
11	30	25	28	9	26	37	0	1 6	19	20	3.8	29.78	02	7.0	7.3	16	36			10		11
12	33	27	30	11	24	35	0		20	.02	T	29.48	02	9.6	10.2	17	03			10	10	12
13	35	22	29	11	27	36	0		20	.03	.8	29.16	34	5.3	5.9	9	04			10	9	13
14	33	9	21	3	26	44	0	1	21	.07	1.3	29.28	01	.4	.4	6	31			10	8	14
15	15	-4	6	-11	1	59	0		22	0	0	29.47	05	2.7	3.6	6	36			0		15
16	16	-5	6	-11		59	0		22	0	0					7	35			0		16
17	21	3	12	-5	2	53	0		21	0	0	29.25	36	8.2	8.9	16	02			0		17
18	6	-21	-8*	-24	-16	73	0		21	0	0	29.41	04	3.6	3.7	12	34			0		18
19	11	-25*	-7	-23	-21	72	0		21	0	0	29.66	03	5.0	5.3	14	02			1	4	19
20	21	10	16	0	8	49	0	1	21	03	.9	29.81	01	12.2	12.9	17	36			10	10	20
21	25	21	23	8	17	42	0	1	22	.01	7	29.79	35	7.4	7.9	14	01			10	10	21
22	31	23	27	12	18	38	0		22	0	0	29.66	01	9.8	10.2	16	01			10		22
23	34	29	32	18		33	0		22	T	T					10	36			10		23
24	37*	28	33*	19	27	32	0		21	T	T	29.51	34	7.1	7.5	12	36			7		24
25	34	16	25	11	20	40	0		21	0	0	29.07	35	6.9	7.6	17	02			10		25
26	30	16	23	10	16	42	0		20	0	0	28.93	36	10.3	10.5	17	35			4	3	26
27	28	7	18	5	17	47	0		20	0	0	28.95	35	5.5	6.3	10	32			8	5	27
28	10	0	5	-8	-1	60	0		20	0	0	28.74	05	3.9	4.0	6	03			1	3	28
29	23	8	16	4	17	49	0		20	.57	7.4	28.65	05	.9	.9	5	05			10		29
30	20	8	14	2		51	0		28	.25	3.1					5	19			10		30
	SUM 724	SUM 280				TOTAL 1441	TOTAL 0	NUMBER OF DAYS		TOTAL 1.70	TOTAL 27.0	FOR THE MONTH:				17	35	TOTAL	% FOR MONTH	SUM 212	SUM	
	AVG. 24.1	AVG. 9.3	AVG. 16.7	DEP. -0.8	AVG.	DEP. 16	DEP. 0	PRECIPITATION > .01 INCH 13		DEP. -0.09						DATE: 26+		POSSIBLE		AVG. 7.1	AVG.	

NUMBER OF DAYS				SEASON TO DATE							
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	SNOW, ICE PELLETS > 1.0 INCH	7	GREATEST IN 24 HOURS AND DATES			
> 90°	≤ 32°	≤ 32°	≤ 0°	3834	1	THUNDERSTORMS	0	PRECIPITATION		SNOW, ICE PELLETS	
9	23	30	7	DEP.	DEP.	HEAVY FOG	0	.67	29-30	8.1	29-30
				280	-5	CLEAR 8	PARTLY CLOUDY 2	CLOUDY 20			

GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
29	30

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
+ ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
BLANK ENTRIES DENOTE MISSING DATA.
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L. Ray Hoxit
ACTING DIRECTOR
NATIONAL CLIMATIC CENTER

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE / NATIONAL CLIMATIC CENTER ASHEVILLE, NORTH CAROLINA

DEC 1982 26528
TALKEETNA, ALASKA
TALKEETNA AIRPORT

ISSN 0198-0424

LOCAL CLIMATOLOGICAL DATA

Monthly Summary

WEA SVC CONTRACT MET OBSY

LATITUDE 62° 18' N LONGITUDE 150° 06' W ELEVATION (GROUND) 345 FEET TIME ZONE ALASKAN WBAN #26528

DEC 1982
TALKEETNA, ALASKA

Date	Temperature °F: Maximum	Minimum	Average	Departure from normal	Average dew point	Degree days base 65°F: Heating (season begins with Jul)	Cooling (season begins with Jan)	Weather types (1 Fog, 2 Heavy fog, 3 Thunderstorm, 4 Ice pellets, 5 Hail, 6 Glaze, 7 Duststorm, 8 Smoke, haze, 9 Blowing snow)	Snow, ice pellets or ice on ground at 08AM (inches)	Precipitation: Water equivalent (inches)	Snow, ice pellets (inches)	Average station pressure in inches, elev. 356 feet above M.S.L.	Wind (M.P.H.): Resultant dir.	Resultant speed	Average speed	Fastest mile: Speed	Direction	Sunshine: Minutes	Percent of total possible	Sky cover (tenths): Sunrise to sunset	Midnight to midnight	Date
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	10	-4	3	-9	0	62	0	1	29	.04	.9	29.11	01	.4	.4	4	01			10		1
2	8	-19*	-6*	-17	-11	71	0		29	0	0	29.13	01	2.8	2.9	16	02			0		2
3	3	-17	-5	-16	-11	70	0		29	0	0	29.06	01	4.2	5.6	12	01			0	0	3
4	16	-17	-1	-12	-7	66	0		29	0	0	29.43	01	12.0	12.5	20	36			9	6	4
5	28	16	22	11	13	43	0		29	T	T	29.54	01	11.5	11.8	20	03			10	10	5
6	31	27	29	19	18	36	0		28	0	0	29.59	01	9.8	9.9	14	36			3		6
7	36	29	33	23		32	0		27	.17	1.1					12	36			10		7
8	34	31	33	23	33	32	0	1	27	.59	3.7	29.30	07	3.3	7.3	16	15			10		9
9	33	17	25	15	21	40	0		26	.02	.8	29.82	04	3.5	8.6	16	15			9		9
10	17	4	11	1	4	54	0		25	0	0	29.56	01	5.0	6.0	8	03			5	3	10
11	28	0	14	5	15	51	0		25	0	0	28.92	35	8.9	9.2	17	34			10	6	11
12	32	25	29	20	21	36	0		24	0	0	28.57	36	10.2	10.8	16	36			10	9	12
13	32	22	27	18	20	38	0		24	0	0	28.63	01	9.4	9.6	16	36			10		13
14	34	21	28	19		37	0		24	0	0					13	02			9		14
15	35	20	28	19	21	37	0		24	0	0	28.51	01	7.9	8.2	16	02			10		15
16	33	22	28	20	21	37	0		24	0	0	29.64	02	10.6	10.9	16	03			9		16
17	31	11	21	13	21	44	0		24	T	T	29.04	35	6.3	6.5	12	33			10	7	17
18	12	3	8	0	4	57	0		24	0	0	29.20	04	4.1	4.2	6	04			6	4	18
19	26	3	15	7	9	50	0		24	0	0	29.00	36	9.8	10.2	23	02			10	7	19
20	28	10	19	11	13	46	0		24	0	0	29.00	01	9.3	9.5	16	01			7		20
21	10	-3	4	-4		61	0		24	0	0					6	03			2		21
22	3	-10	-4	-12	-11	69	0		24	0	0	28.85	01	3.8	5.3	7	33			0		22
23	15	2	9	1	-2	56	0		24	0	0	28.93	01	9.8	10.2	15	36			2		23
24	22	12	17	9	9	48	0		24	0	0	29.09	35	7.1	7.8	12	01			7	7	24
25	23	12	18	10	10	47	0		24	0	0	29.37	35	7.0	7.3	14	01			10	8	25
26	33	22	28	20	16	37	0		24	0	0	29.39	02	13.1	13.4	17	01			10	10	26
27	34	30	32	24	29	33	0	1	24	.30	2.5	29.48	01	5.4	6.3	16	01			10		27
28	38	32	35	27		30	0		25	.64	.8					12	02			10		28
29	42*	32	37*	29	34	28	0		24	.04	.5	29.41	01	1.9	4.2	13	16			10		29
30	35	26	31	23	29	34	0		23	T	T	29.55	05	2.2	4.2	9	01			10		30
31	31	25	28	20	21	37	0		23	0	0	29.52	35	7.0	7.6	10	33			8	10	31
	SUM 798	SUM 384				TOTAL 1419	TOTAL 0	NUMBER OF DAYS		TOTAL 1.80	TOTAL 10.3	FOR THE MONTH:				23	02	TOTAL	% FOR MONTH	SUM 236	SUM	
	AVG. 25.7	AVG. 12.4	AVG. 19.1	DEP. 10.1	AVG.	DEP. -317	DEP. 0	PRECIPITATION > .01 INCH. 7		DEP. 0.09						DATE: 19		POSSIBLE		AVG. 7.6	AVG.	

NUMBER OF DAYS				SEASON TO DATE			GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	SNOW, ICE PELLETS > 1.0 INCH 3	PRECIPITATION		SNOW, ICE PELLETS			
≥ 90°	≤ 32°	≤ 32°	≤ 0°	5253	1	THUNDERSTORMS 0	.81	27-28	4.4	7-8	30	1
0	20	31	7	DEP. -37	DEP. -5	HEAVY FOG 0						
						CLEAR 6 PARTLY CLOUDY 4 CLOUDY 21						

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
+ ALSO ON EARLIER DATE(S).
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JAN 1983 26528
TALKEETNA, ALASKA
TALKEETNA AIRPORT

ISSN 0198-0424

LOCAL CLIMATOLOGICAL DATA
Monthly Summary

WEA SVC CONTRACT MET OBSY

LATITUDE 62° 18' N LONGITUDE 150° 06' W ELEVATION (GROUND) 345 FEET TIME ZONE ALASKAN WBAN #26528

JAN 1983
TALKEETNA, ALASKA

DATE 1	TEMPERATURE °F: MAXIMUM 2	MINIMUM 3	AVERAGE 4	DEPARTURE FROM NORMAL 5	AVERAGE DEW POINT 6	DEGREE DAYS BASE 65°F: HEATING (SEASON BEGINS WITH JUL) 7A	COOLING (SEASON BEGINS WITH JAN) 7B	WEATHER TYPES (1 FOG, 2 HEAVY FOG, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW) 8	SNOW ICE PELLETS OR ICE ON GROUND AT 08AM INCHES 9	PRECIPITATION: WATER EQUIVALENT (INCHES) 10	SNOW, ICE PELLETS (INCHES) 11	AVERAGE STATION PRESSURE IN INCHES ELEV. 356 FEET ABOVE M.S.L. 12	WIND (M.P.H.): RESULTANT DIR. 13	RESULTANT SPEED 14	AVERAGE SPEED 15	FASTEST MILE: SPEED 16	DIRECTION 17	SUNSHINE: MINUTES 18	PERCENT OF TOTAL POSSIBLE 19	SKY COVER (TENTHS): SUNRISE TO SUNSET 20	MIDNIGHT TO MIDNIGHT 21	DATE 22
1	33	27	30	22	23	35	0		23	0	0	29.24	01	5.8	5.9	12	02			10	9	1
2	34	25	30	22	23	35	0		23	0	0	29.07	35	6.4	6.5	10	01			9	10	2
3	27	24	26	18	22	39	0	1	23	.16	3.8	29.10	36	8.7	9.2	15	01			10		3
4	26	-7	10	2		55	0		26	0	0					12	02			0		4
5	10	-10	0	-8	-10	65	0		26	0	0	29.10	01	7.3	7.6	14	03			0		5
6	-2	-18	-10	-18	-16	75	0		26	T	T	28.56	01	3.2	3.3	9	03			2		6
7	-2	-21	-12	-20	-14	77	0		26	.01	.2	28.48	30	2.1	3.2	7	31			6	7	7
8	-2	-30*	-16*	-24	-30	81	0		26	0	0	29.18	02	3.1	3.5	17	03			0	0	8
9	1	-12	-6	-14	-19	71	0		26	0	0	29.58	02	8.5	9.2	17	03			0	0	9
10	6	-12	-3	-11	-18	68	0		26	0	0	29.48	01	10.6	11.4	21	01			0		10
11	11	4	8	0		57	0		26	0	0					21	03			0		11
12	9	-3	3	-5	-12	62	0		25	0	0	28.98	03	9.4	9.5	17	02			7		12
13	6	-1	3	-6	-16	62	0		25	0	0	29.19	02	10.9	11.4	17	02			1		13
14	13	-10	2	-7	-9	63	0		25	0	0	29.14	03	3.1	3.2	13	03			2	4	14
15	36	13	25	16	11	40	0		25	0	0	29.18	01	9.2	9.5	18	35			10	9	15
16	34	25	30	21	20	35	0	1	25	.12	2.3	28.86	36	5.2	7.2	13	01			10	10	16
17	25	11	18	9	17	47	0	1	27	.07	1.2	28.84	36	1.0	1.2	6	34			10		17
18	36	13	25	16		40	0		28	T	T					15	03			10		18
19	35	20	28	18	23	37	0	1	28	.10	•4.4	29.13	14	2.2	6.6	13	15			10		19
20	26	21	24	14	14	41	0		32	0	0	29.57	01	9.1	9.5	14	02			9		20
21	28	3	16	6	7	49	0		32	0	0	29.57	36	7.3	7.8	13	35			9	8	21
22	8	-8	0	-10	-8	65	0		30	0	0	29.56	03	2.7	2.7	7	03			0	0	22
23	11	-11	0	-10	-7	65	0		30	0	0	29.27	05	2.0	2.2	6	21			0	0	23
24	25	-14	6	-5	-6	59	0		30	0	0	29.06	01	4.8	5.9	13	03			7		24
25	25	19	22	11		43	0		29	0	0					17	36			4		25
26	31	25	28	17	15	37	0		29	0	0	28.56	01	11.4	11.8	16	02			10		26
27	29	14	22	11	16	43	0		29	0	0	26.75	35	4.3	4.9	14	03			9		27
28	29	7	18	7	16	47	0		29	0	0	29.14	36	4.1	4.5	9	01			6	6	28
29	29	4	17	5	10	48	0		29	0	0	28.93	35	5.1	5.3	10	33			0	0	29
30	29	4	17	5	14	48	0		29	0	0	28.96	01	11.5	11.7	16	01			9	6	30
31	38*	27	33*	21	23	32	0		29	0	0	29.22	36	6.5	7.8	14	02			9		31

	Maximum	Minimum	Average	Departure	Avg. dew point	Heating	Cooling
	SUM	SUM				TOTAL	TOTAL
	644	129				1621	0
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.
	20.8	4.2	12.5	4.1		-103	0

NUMBER OF DAYS				SEASON TO DATE	
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL
≥ 90°	≤ 32°	≤ 32°	≤ 0°	6874	0
				DEP.	DEP.
0	24	31	13	-140	0

NUMBER OF DAYS	
PRECIPITATION ≥ .01 INCH.	5
SNOW, ICE PELLETS ≥ 1.0 INCH	4
THUNDERSTORMS	0
HEAVY FOG	0
CLEAR 12	PARTLY CLOUDY 5 CLOUDY 14

Precipitation water equivalent	Snow, ice pellets	FOR THE MONTH: fastest mile speed	Direction	Sunshine total	% of possible	Sky cover sunrise to sunset	Midnight to midnight
TOTAL	TOTAL			TOTAL	% FOR MONTH	SUM	SUM
.46	11.9	21	03			169	
DEP.		DATE: 11+		POSSIBLE		AVG.	AVG.
-0.99						5.5	

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
.19	16-17	4.4	19	33	19

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
• ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
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FEB 1983
TALKEETNA, ALASKA

WEATHER TYPES (col. 8): 1 FOG, 2 HEAVY FOG, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65°F HEATING (SEASON BEGINS WITH JUL)	COOLING (SEASON BEGINS WITH JAN)	WEATHER TYPES	SNOW ICE PELLETS OR ICE ON GROUND AT 08AM INCHES	PRECIPITATION WATER EQUIVALENT (INCHES)	SNOW, ICE PELLETS (INCHES)	AVERAGE STATION PRESSURE IN INCHES ELEV. 356 FEET ABOVE M.S.L.	WIND (M.P.H.) RESULTANT DIR.	RESULTANT SPEED	AVERAGE SPEED	FASTEST MILE SPEED	DIRECTION	SUNSHINE MINUTES	PERCENT OF TOTAL POSSIBLE	SKY COVER (TENTHS) SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	42*	28	35*	23		30	0		28	0	0					14	02			9		1
2	37	23	30	18	24	35	0		28	0	0	29.20	01	6.2	7.1	15	05			10		2
3	35	27	31	19	23	34	0		28	0	0	29.20	01	6.1	6.8	15	05			9		3
4	36	22	29	17	21	36	0		27	0	0	29.04	01	8.2	8.6	17	02			10	10	4
5	39	27	33	20	26	32	0		27	.02	.8	28.78	01	4.1	6.0	12	01			10	9	5
6	32	26	29	16	23	36	0		27	.05	1.3	28.70	04	1.7	5.5	12	02			10	9	6
7	32	20	26	13	25	39	0	1	29	.11	2.3	28.95	07	.7	3.6	6	17			9		7
8	26	1	14	1		51	0	1	30	.03	1.2					6	29			9		8
9	22	-7	8	-6	- 3	57	0		31	0	0	29.16	04	3.8	4.0	7	02			0		9
10	4	-15	-6	-20	-14	71	0		31	0	0	29.14	02	1.4	1.4	5	02			4		10
11	8	-19	-6	-20	-16	71	0		31	0	0	28.92	36	.9	2.2	5	03			2	1	11
12	5	-22	-9*	-23	-18	74	0		31	0	0	28.90	33	.1	.9	5	04			1	0	12
13	12	-23*	-6	-20	-13	71	0		31	0	0	29.29	01	3.1	3.9	7	32			0	2	13
14	20	-10	5	-10	- 2	60	0		31	0	0	29.49	35	5.0	5.5	9	01			2		14
15	25	-12	7	-8		58	0		30	0	0					13	02			1		15
16	27	11	19	4	4	46	0		30	0	0	29.19	01	9.2	9.6	17	03			0		16
17	27	8	18	3	- 2	47	0		30	0	0	28.87	01	9.6	9.9	16	03			0		17
18	22	8	15	0	5	50	0	1	29	.12	3.2	28.86	01	10.5	10.9	15	03			10	7	18
19	32	10	21	6	16	44	0		32	T	T	28.93	36	8.6	8.9	16	02			3	4	19
20	35	10	23	8	17	42	0	1	31	T	.3	28.89	36	7.1	7.5	16	01			9	9	20
21	37	25	31	15	17	34	0		31	0	0	29.17	01	7.9	8.1	16	01			10		21
22	41	14	28	12		37	0		30	0	0					12	02			1		22
23	37	13	25	9	17	40	0		30	0	0	28.67	01	9.1	9.5	14	03			7		23
24	35	18	27	11	24	38	0	1	29	.04	.8	28.90	01	4.5	4.8	13	03			10		24
25	36	2	19	3	12	46	0		30	0	0	28.93	02	4.1	4.3	12	02			1	3	25
26	37	18	28	12	19	37	0		30	0	0	28.93	36	8.9	9.4	15	02			10	9	26
27	35	13	24	8	16	41	0		29	0	0	29.16	34	4.2	6.2	12	02			10	10	27
28	32	12	22	6	25	43	0		29	.09	1.1	29.41	32	1.9	2.3	7	33			10		28
	SUM 308	SUM 228				TOTAL 1300	TOTAL 0	NUMBER OF DAYS		TOTAL .46	TOTAL 11.0	FOR THE MONTH:				17	03	TOTAL	% FOR MONTH	SUM 167	SUM	
	AVG. 28.9	AVG. 8.1	AVG. 18.5	DEP. 4.1	AVG.	DEP. -92	DEP. 0	PRECIPITATION ≥ .01 INCH 7		DEP. -1.07						DATE: 16+		POSSIBLE		AVG. 6.0	AVG.	

NUMBER OF DAYS MAXIMUM TEMP. ≥ 90°	MAXIMUM TEMP. ≤ 32°	MINIMUM TEMP. ≤ 32°	MINIMUM TEMP. ≤ 0°	SEASON TO DATE HEATING TOTAL	COOLING TOTAL
0	15	28	7	9174	0
				DEP. -232	DEP. 0

NUMBER OF DAYS	
SNOW, ICE PELLETS ≥ 1.0 INCH	5
THUNDERSTORMS	0
HEAVY FOG	0
CLEAR 11	PARTLY CLOUDY 2 CLOUDY 15

GREATEST IN 24 HOURS AND DATES PRECIPITATION	DATE	SNOW, ICE PELLETS	DATE	GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	DATE
.12	18	3.2	18	32	19+

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
+ ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
BLANK ENTRIES DENOTE MISSING OR UNREPORTED DATA.
HOURS OF OPS. MAY BE REDUCED ON A VARIABLE SCHEDULE.

$$ NOTE: JAN 1983 - COL. 5 DAILY DATA COMPUTED FROM 1941-70 NORMALS. $$

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L. Ray Hoxit
ACTING DIRECTOR
NATIONAL CILMATIC DATA CENTER

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NATIONAL ENVIRONMENTAL SATELLITE, DATA AND INFORMATION SERVICE NATIONAL CLIMATIC DATA CENTER ASHEVILLE NORTH CAROLINA

MAR 1983 26529
TALKEETNA, ALASKA
TALKEETNA AIRPORT

ISSN [illegible]-0424

LOCAL CLIMATOLOGICAL DATA

Monthly Summary

WEA SVC CONTRACT MET OBSY

LATITUDE 62° 18' N LONGITUDE 150° 06' W ELEVATION (GROUND) 345 FEET TIME ZONE ALASKAN WBAN #26529

DATE 1	TEMPERATURE °F: MAXIMUM 2	MINIMUM 3	AVERAGE 4	DEPARTURE FROM NORMAL 5	AVERAGE DEW POINT 6	DEGREE DAYS BASE 65°F: HEATING (SEASON BEGINS WITH JUL) 7A	COOLING (SEASON BEGINS WITH JAN) 7B	WEATHER TYPES (1 FOG, 2 HEAVY FOG, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW) 8	SNOW ICE PELLETS OR ICE ON GROUND AT 08AM INCHES 9	PRECIPITATION: WATER EQUIVALENT (INCHES) 10	SNOW, ICE PELLETS (INCHES) 11	AVERAGE STATION PRESSURE IN INCHES ELEV. 356 FEET ABOVE M.S.L. 12	WIND (M.P.H.): RESULTANT DIR 13	RESULTANT SPEED 14	AVERAGE SPEED 15	FASTEST MILE: SPEED 16	FASTEST MILE: DIRECTION 17	SUNSHINE: MINUTES 18	PERCENT OF TOTAL POSSIBLE 19	SKY COVER (TENTHS): SUNRISE TO SUNSET 20	MIDNIGHT TO MIDNIGHT 21	DATE 22
1	32	8	20	4		45	0		30	T	T					4	35			[illegible]		1
2	29	-5	12	-4	3	53	0		30	0	0	29.36	31	1.[illegible]	2.7	7	28			[illegible]		2
3	26	-10*	8*	-3	-1	57	0		29	0	0	29.36	02	4.[illegible]	4.6	9	04			[illegible]		3
4	26	8	17	1	8	48	0		29	0	0	29.[illegible]	35	6.3	6.5	9	36			10	9	4
5	31	19	25	9	16	40	0	1	29	.02	.7	29.[illegible]	01	[illegible]	7.9	14	01			10	9	5
6	34	15	25	9	14	40	0		29	0	0	29.57	36	7.4	7.6	12	02			9	7	6
7	36	5	21	4	9	44	0		29	0	0	29.50	36	4.[illegible]	4.5	9	02			4		7
8	37	-5	16	-1		49	0		29	0	0					10	20			3		8
9	35	7	21	4	8	44	0		29	0	0	28.71	36	3.5	5.3	9	35			0		9
10	27	-2	13	-4	12	52	0		28	.01	.3	28.[illegible]	35	3.[illegible]	4.4	9	01					10
11	40	18	29	12	20	36	0		28	0	0	28.[illegible]	36	4.[illegible]	4.3	10	02			3	9	11
12	47*	21	34*	16	22	31	0		28	0	0	29.[illegible]	36	4.[illegible]	5.2	12	36			[illegible]	6	12
13	46	14	30	12	18	35	0		28	0	0	29.[illegible]	35	2.[illegible]	3.2	7	02			[illegible]	2	13
14	41	22	32	14	22	33	0		25	0	0	29.[illegible]	29	3.[illegible]	3.7	7	27			9		14
15	43	21	32	14		33	0		25	.05	.8					7	27			[illegible]		15
16	45	19	32	13	22	33	0		24	0	0	29.82	36	5.[illegible]	5.8	13	36			4		16
17	44	9	27	[illegible]	15	38	0		24	0	0	29.[illegible]	32	[illegible]	3.2	7	29			3		17
18	40	7	24	5	16	41	0		23	0	0	29.[illegible]	34	3.[illegible]	4.3	5	27			0	0	18
19	40	6	23	3	14	42	0		22	0	0	29.[illegible]	33	[illegible]	3.6	7	28			[illegible]	1	19
20	41	23	32	12	19	33	0		20	0	0	29.[illegible]	35	5.[illegible]	6.0	8	36			3	9	20
21	43	19	31	11	18	34	0		20	0	0	29.40	32	3.[illegible]	4.8	9	27					21
22	41	9	25	4		40	0		19	0	0					8	27					22
23	40	11	25	5	15	39	0		18	0	0	29.35	33	[illegible]	3.6	8	27					23
24	37	11	24	[illegible]	20	41	0		18	.01	.3	29.34	36	4.4	5.9	9	05					24
25	41	20	31	9	20	34	0		18	0	0	29.[illegible]	36	[illegible]	7.3	13	01			[illegible]	5	25
26	41	24	33	11	19	32	0		18	0	0	29.17	35	[illegible]	7.5	13	36			7	7	26
27	40	25	33	10	19	32	0		17	0	0	29.04	36	4.4	9.6	13	35			6	4	27
28	44	22	33	10	19	32	0		17	0	0	29.06	35	7.[illegible]	7.6	15	36					28
29	44	15	30	6		35	0		17	0	0					8	27					29
30	43	16	30	5	17	35	0		17	0	0	28.92	33	[illegible]	3.7	8	27					30
31	45	21	33	4	22	32	0		17	0	0	29.15	32	[illegible]	3.2	8	28					31

	MAXIMUM	MINIMUM	AVERAGE	DEPARTURE	DEW POINT	HEATING	COOLING
	SUM	SUM				TOTAL	TOTAL
	1199	393				1213	0
	AVG.	AVG	AVG.	DEP	AVG.	DEP.	DEP.
	39.7	12.7	25.7	6.4		-182	0

NUMBER OF DAYS				SEASON TO DATE TOTAL (HEATING)	TOTAL (COOLING)
MAXIMUM TEMP ≥ 90°	≤ 32°	MINIMUM TEMP ≤ 32°	≤ 0°	9387	0
				DEP.	DEP.
0	0	31	4	-414	0

NUMBER OF DAYS	
PRECIPITATION ≥ .01 INCH	4
SNOW, ICE PELLETS ≥ 1.0 INCH	0
THUNDERSTORMS	0
HEAVY FOG	0
CLEAR	PARTLY CLOUDY CLOUDY

	WATER EQUIVALENT	SNOW, ICE PELLETS	FASTEST MILE SPEED	DIRECTION	SUNSHINE	%	SKY COVER SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT
	TOTAL	TOTAL	FOR THE MONTH:		TOTAL	% FOR MONTH	SUM	SUM
	09	2.1	15	36				
	DEP.		DATE: 28		POSSIBLE		AVG.	AVG
	-1.40							

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
05	15	.8	15	30	5+

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON EARLIER DATE(S)
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
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MAR 1983
TALKEETNA, ALASKA

WS FORM F-6

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

PRELIMINARY LOCAL CLIMATOLOGICAL DATA

STATION: WSCMO, TALKEETNA, ALASKA
MONTH: APRIL YEAR: 1983

LATITUDE: 62 ° 18 ' N LONGITUDE: 150 ° 06 ' W GROUND ELEVATION (ft): 345 FT. STANDARD TIME: ALASKAN

DAY	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	DEGREE DAYS (Base 65°): HEATING	COOLING	PRECIPITATION (In.): TOTAL (Water equivalent)	SNOWFALL, ICE PELLETS	SNOW, ICE PELLETS OR ICE ON GROUND AT 0800A	WIND: AVERAGE SPEED (m.p.h.)	FASTEST MILE: SPEED (m.p.h.)	DIRECTION	SUNSHINE: TOTAL (Hrs.)	PERCENT OF POSSIBLE	SKY COVER SUNRISE TO SUNSET (Tenths)	WEATHER OCCURRENCES	17	18	19	20
1	2	3	4	5	6a	6b	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	45	17	31	+5	34	0	0	0	17	4.2	7	27 2/			4					
2	48	18	33	+7	32	0	0	0	17	2.8	6	20 2/			0					
3	47	17	32	+5	33	0	0	0	16	5.7	12	02			2					
4	42	30	36	+9	29	0	.10	(1.0)	16	(5.1)	13	14 2/	23		M					
5	37	22	30	+2	35	0	.22	(1.5)	16+	2.2	6	05 2/	18		M	1	O	8		
6	42	28	35	+7	30	0	T	T	17	(4.2)	7	05 2/	23		M					
7	42	23	33	+4	32	0	0	0	16	2.5	6	28 2/	23		M					
8	38	25	32	+2	33	0	T	T	16	4.3	7	23			4					
9	36	24	30	0	35	0	.01	0.4	16	3.9	7	21 2/			7	1				
10	35	19	27	-4	38	0	T	T	15	(2.8)	8	02			7					
11	26	14	20	-11	45	0	.24	5.3	15	5.2	9	02	23		M	1				
12	35	22	29	-3	36	0	.29	(7.4)	21+	(3.6)	8	01	18		M	1	O	8		
13	43	27	35	+3	30	0	T	T	20	(3.1)	7	28 2/	23		M	1				
14	40	31	36	+4	29	0	.23	(1.9)	18	(2.2)	6	02 2/	23		M	1				
15	38	32	35	+2	30	0	.32	(1.1)	19	3.2	7	01			10	1				
16	44	31	38	+5	27	0	.04	(6.5)	13	5.4	15	02			10	1				
17	40	22	31	-3	34	0	.40	6.2	12	3.0	12	19			8	1				
18	43	30	37	+1	28	0	.11	1.7	19	2.9	8	33 2/	23		M	1				
19	44	30	37	+2	28	0	.02	(0.2)	19+	(3.7)	7	25 2/	18		M		O	8		
20	48	29	39	+4	26	0	0	0	18	4.5	9	03	23		M					
21	47	27	38	+2	27	0	0	0	16	(2.9)	7	27	23		M					
22	48	33	41	+5	24	0	.10	0	14	2.6	7	01 2/			10	1				
23	43	35	39	+3	26	0	.16	0	13	3.4	7	32			10	1				
24	57	32	45	+8	20	0	0	0	12	4.1	8	28	23		M					
25	62	29	46	+9	19	0	0	0	10	(4.0)	8	19	22		M					
26	55	29	42	+4	23	0	0	0	7	1.3	5	28 2/	17		M		O	8		
27	57	27	42	+4	23	0	0	0	5	(2.1)	6	18	23		M					
28	43	30	37	-1	28	0	.11	0	3	1.0	5	20	23		M	1				
29	48	32	40	+1	25	0	.23	0	2	0.7	5	28 2/			10	1				
30	58	29	44	+5	21	0	0	0	1	3.7	10	02			1					
31																				
SUM	1333	794	—	—	880	0	2.58	26.7	—	100.9	—	—		—	M	—				
AVG	44.4	26.5	—	—	—	—	—	—	—	3.4	FASTEST 15	DIRECTION 02	POSSIBLE		M	—				

TEMPERATURE DATA

AVERAGE MONTHLY: 35.5
DEPARTURE FROM NORMAL: + 2.6
HIGHEST: 62 ON 25
LOWEST: 14 ON 11
NUMBER OF DAYS WITH –
MAX. 32° OR BELOW: 1
MAX 70° OR ABOVE: 0
MIN 32° OR BELOW: 28
MIN 0° OR BELOW: 0

HEATING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 880
DEPARTURE FROM NORMAL: – 42
SEASONAL TOTAL: 10267
DEPARTURE FROM NORMAL: – 506

COOLING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 0
DEPARTURE FROM NORMAL: 0
SEASONAL TOTAL: 0
DEPARTURE FROM NORMAL: 0

PRECIPITATION DATA

TOTAL FOR THE MONTH: 2.58 IN.
DEPARTURE FROM NORMAL: + 1.22 IN.
GREATEST IN 24 HRS.: .51 ON 17-18

SNOWFALL, ICE PELLETS
TOTAL FOR THE MONTH: 26.7 IN.
GREATEST IN 24 HRS.: 9.7 ON 11-12
GREATEST DEPTH ON GROUND: 22 ON 12

PRESSURE DATA
HIGHEST SEA-LEVEL: 30.32 IN. ON 8
LOWEST SEA-LEVEL: 29.21 IN. ON 4

WEATHER

NUMBER OF DAYS –
CLEAR (Scale 0-3): M
PARTLY CLOUDY (Scale 4-7): M
CLOUDY (Scale 8-10): M
WITH 0.01 INCH OR MORE PRECIP.: 15
WITH 0.10 INCH OR MORE PRECIP.: 12
WITH 0.50 INCH OR MORE PRECIP.: 0
WITH 1.00 INCH OR MORE PRECIP.: 0

SYMBOLS USED IN COLUMN 16

1 = FOG
2 = FOG REDUCING VISIBILITY TO 1/4 MILE OR LESS
3 = THUNDER
4 = ICE PELLETS
5 = HAIL
6 = GLAZE OR RIME
7 = BLOWING DUST OR BLOWING SAND REDUCING VISBY TO 1/4 MILE OR LESS
8 = SMOKE OR HAZE
9 = BLOWING SNOW
T = TORNADO

MAXIMUM PRECIPITATION

Δt (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
PRECIPITATION (Inches)												
ENDED: DATE												
TIME												

* Average wind speed is based on 24 hours unless otherwise indicated.
# Fastest one minute wind speed and its direction.
@ Synoptic data is based on 6 hours unless otherwise indicated.
+ Snow data is obtained at 0800A where indicated.
2/ Indicates only the last of several occurrences.

WS FORM F-6 SUPERSEDES WS FORM F-6 WHICH SHOULD BE USED UNTIL EXISTING STOCK IS DEPLETED. U.S. G.P.O.

WS FORM F-6

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

PRELIMINARY LOCAL CLIMATOLOGICAL DATA

STATION: WSCMO, TALKEETNA, ALASKA
MONTH: MAY
YEAR: 1983
LATITUDE: 62° 18' N
LONGITUDE: 150° 06' W
GROUND ELEVATION (FT): 345 FT.
STANDARD TIME: ALASKAN

Day	Temp °F Maximum	Minimum	Average	Departure from normal	Degree days (base 65°) Heating	Cooling	Precip. Total (water equiv.)	Snowfall, ice pellets	Snow, ice pellets or ice on ground at 0200A	Wind * Average speed (m.p.h.)	Fastest mile # Speed (m.p.h.)	Direction	Sunshine * Total (hrs.)	Percent of possible	Sky cover sunrise to sunset (tenths)	Weather occurrences	2/ 0300	2/ 0900	19	20
1	2	3	4	5	6a	6b	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	56	27	42	+3	23	0	.06	0	0	3.3	7	27			8	1				
2	44	36	40	0	25	0	.46	0	0	2.5	4	20	23		M	1				
3	48	31	40	0	25	0	.01	0	0+	(2.6)	7	13	11		M	1	0	4		
4	53	32	43	+3	22	0	.23	0	0	2.5	7	21	23		M					
5	52	32	42	+1	23	0	.12	0	0	(2.2)	4	06	22		M					
6	56	29	43	+2	22	0	0	0	0	2.1	6	24			6					
7	62	28	45	+4	20	0	0	0	0	3.3	4	21			[illegible]					
8	62	29	46	+4	19	0	0	0	0	5.1	7	16			2					
9	54	41	48	+6	17	0	T	0	0	3.5	6	13	23		M					
10	60	33	47	+5	18	0	0	0	0+	4.5	7	17	11		M		0	8		
11	62	34	48	+5	17	0	0	0	0	4.4	10	14	23		M					
12	60	41	51	+8	14	0	0	0	0	(2.2)	7	16	22		M					
13	61	40	51	+7	14	0	0	0	0	4.7	10	16			4					
14	60	44	52	+8	13	0	.03	0	0	4.6	16	16			10					
15	57	42	50	+6	15	0	.01	0	0	4.6	13	14			4					
16	54	38	46	+1	19	0	.04	0	0	3.7	7	06	23		M					
17	53	39	46	+1	19	0	.16	0	0+	5.0	12	19	11		M		0	8		
18	55	39	47	+2	18	0	T	0	0	4.4	8	14	23		M					
19	59	37	48	+2	17	0	0	0	0	(4.6)	12	17	23		M					
20	66	46	56	+10	9	0	0	0	0	13.1	21	18			3					
21	53	44	49	+3	16	0	.06	0	0	5.6	12	14			10					
22	56	43	50	+3	15	0	.11	0	0	4.7	1	15			10					
23	55	39	47	0	18	0	.06	0	0	(2.6)	4	32	22		M					
24	63	41	52	+5	13	0	.01	0	0+	7.2	14	01	14		M		0	8		
25	64	32	48	0	17	0	0	0	0	7.2	15	21	23		M					
26	60	39	50	+2	15	0	T	0	0	5.6	13	16	23		M					
27	59	35	47	2	18	0	0	0	0	(4.4)	8	31			8					
28	67	34	51	+4	14	0	0	0	0	4.7	16	27			6					
29	62	44	53	+6	12	0	.38	0	0	(4.6)	4	18			10					
30	71	50	61	+11	4	0	.04	0	0	5.5	12	13	22		M					
31	62	45	54	+7	11	0	.14	0	0+	2.5	12	22	11		M	1	0	8		
Sum	1814	1160	—	—	530	0	1.27	0	—	145.5	—	—		—	M	—				
Avg	58.5	37.4	—	—	—	—	—	—	—	4.7	Fastest: 21	Direction: 18		Possible	M	—				

TEMPERATURE DATA

AVERAGE MONTHLY: 48.0
DEPARTURE FROM NORMAL: +3.4
HIGHEST: 71 ON 30
LOWEST: 27 ON 1
NUMBER OF DAYS WITH –
MAX. 32° OR BELOW: 0
MAX. 70° OR ABOVE: 1
MIN. 32° OR BELOW: 8
MIN. 0° OR BELOW: 0
HEATING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 530
DEPARTURE FROM NORMAL: -104
SEASONAL TOTAL: 10787
DEPARTURE FROM NORMAL: -615
COOLING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 0
DEPARTURE FROM NORMAL: 0
SEASONAL TOTAL: 0
DEPARTURE FROM NORMAL: 0

PRECIPITATION DATA

TOTAL FOR THE MONTH: 1.27 IN.
DEPARTURE FROM NORMAL: -.12 IN.
GREATEST IN 24 HRS.: .32 ON 1-2
SNOWFALL, ICE PELLETS
TOTAL FOR THE MONTH: 0 IN.
GREATEST IN 24 HRS: — ON —
GREATEST DEPTH ON GROUND: — ON —
PRESSURE DATA
HIGHEST SEA-LEVEL: 30.47 IN. ON 10
LOWEST SEA-LEVEL: 29.30 IN. ON 25

WEATHER

NUMBER OF DAYS –
CLEAR (Scale 0–3): M
PARTLY CLOUDY (Scale 4–7): M
CLOUDY (Scale 8–10): M
WITH 0.01 INCH OR MORE PRECIP.: 16
WITH 0.10 INCH OR MORE PRECIP.: 2
WITH 0.50 INCH OR MORE PRECIP.: 0
WITH 1.00 INCH OR MORE PRECIP.: 0

SYMBOLS USED IN COLUMN 16

1 = FOG
2 = FOG REDUCING VISIBILITY TO 1/4 MILE OR LESS
3 = THUNDER
4 = ICE PELLETS
5 = HAIL
6 = GLAZE OR RIME
7 = BLOWING DUST OR BLOWING SAND REDUCING VISIBILITY TO 1/4 MILE OR LESS
8 = SMOKE OR HAZE
9 = BLOWING SNOW
T = TORNADO

MAXIMUM PRECIPITATION												
Δt (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
PRECIPITATION (Inches)												
ENDED: DATE												
TIME												

* Average wind speed is based on 24 hours unless otherwise indicated.
\# Fastest one minute wind speed and its direction.
\+ Snow data is obtained at 0300A where indicated.
1/ Indicates only the last of several occurrences.
2/ Synoptic data is based on 6 hours unless otherwise indicated.

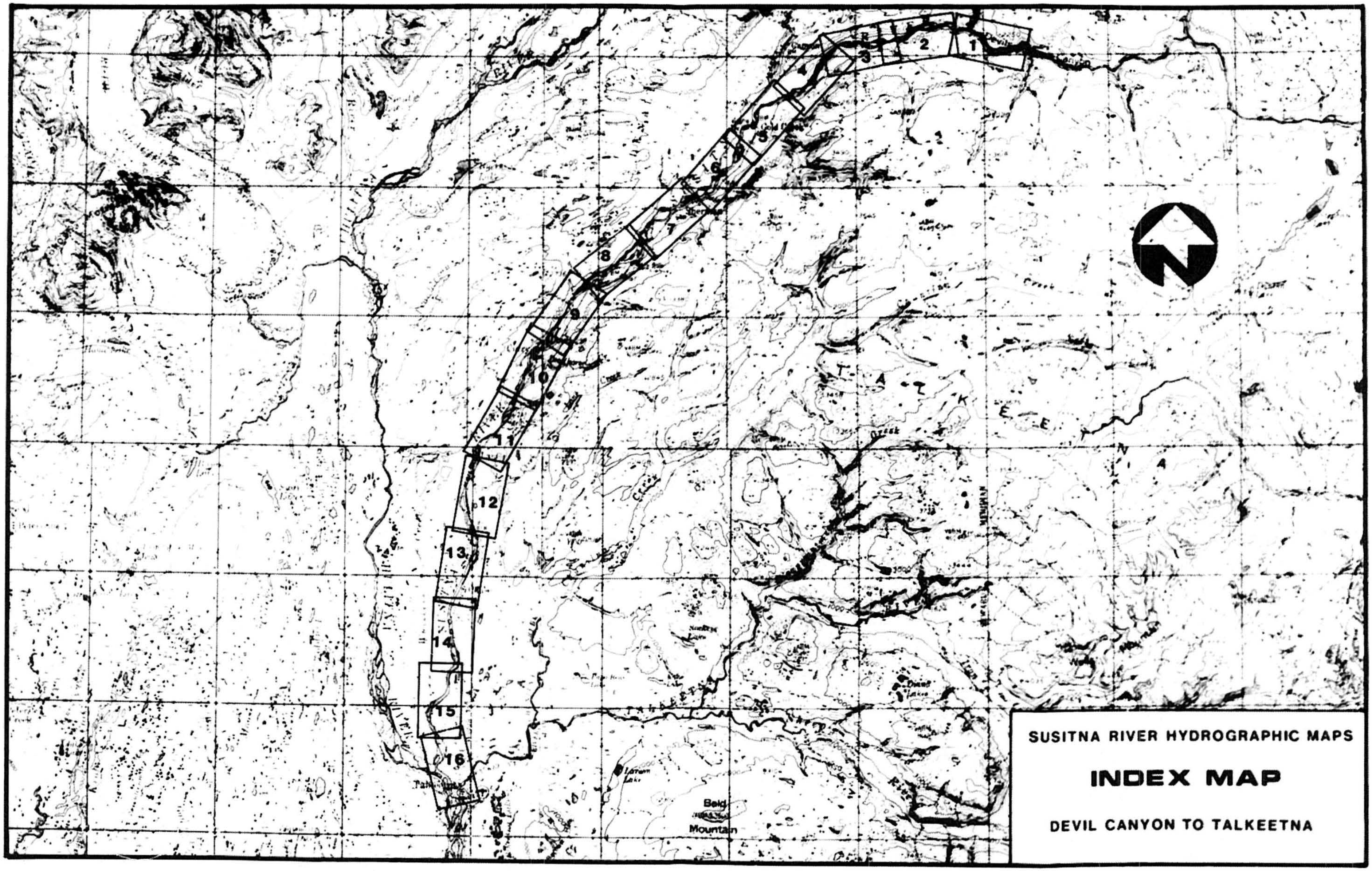
WS FORM F-6 SUPERSEDES WS FORM F-6 WHICH SHOULD BE USED UNTIL EXISTING STOCK IS DEPLETED.

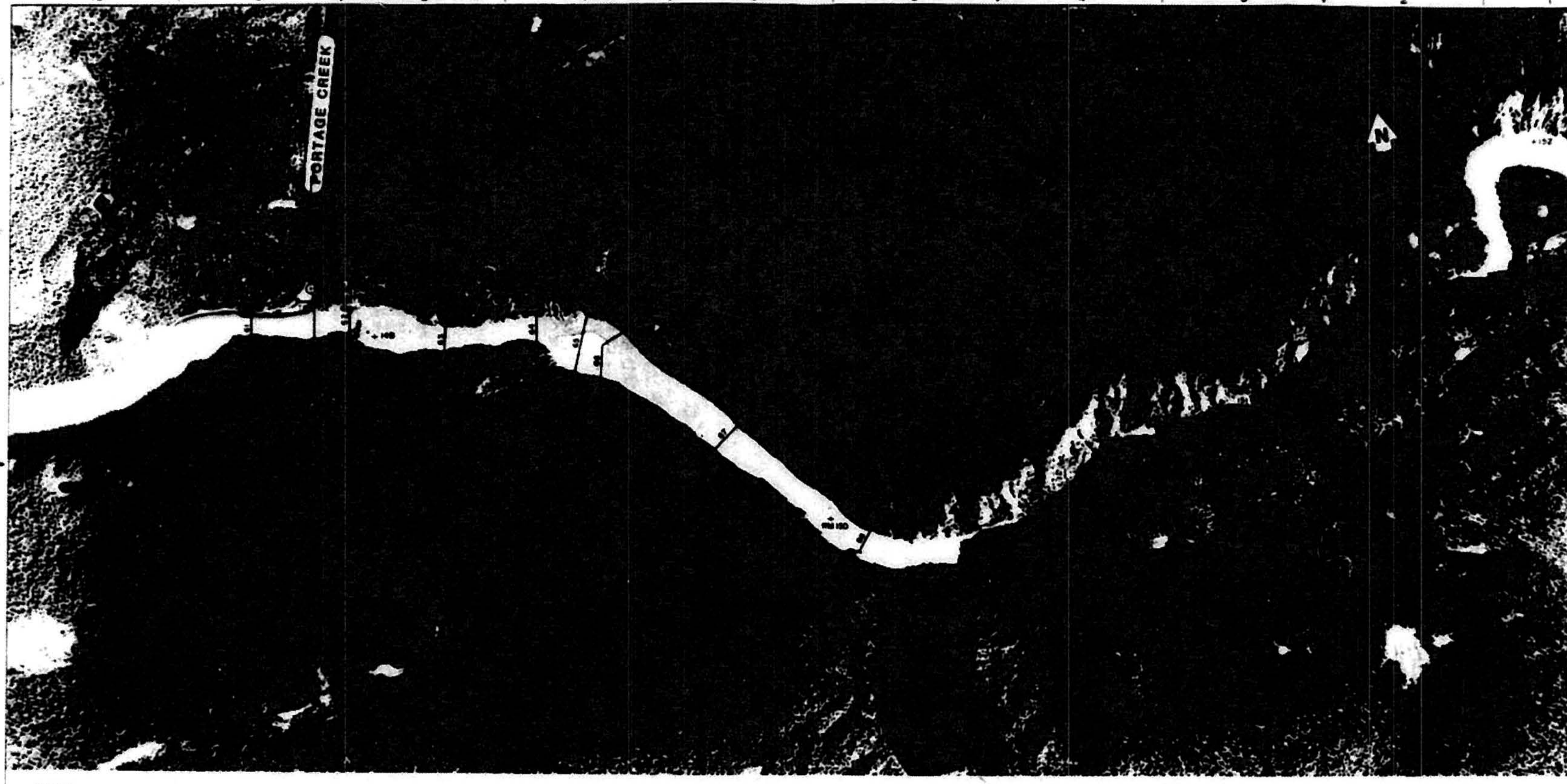
U.S. G.P.O.

s16/y5

APPENDIX B

Susitna River Maps (Aerial Photo Mosaics) from Goose Creek to Devil Canyon


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Belg
Mountain
SUSITNA RIVER HYDROGRAPHIC MAPS
INDEX MAP
DEVIL CANYON TO TALKEETNA



NOTES:

1. SOLID LINES DEPICT CROSS SECTION
2. TEMPORARY BENCHMARKS ARE LOCATED AT EACH END OF EVERY CROSS SECTION
3. NUMBERS REFER TO THE LRX DESIGNATION

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUSITNA RIVER

HYDROGRAPHIC MAPS

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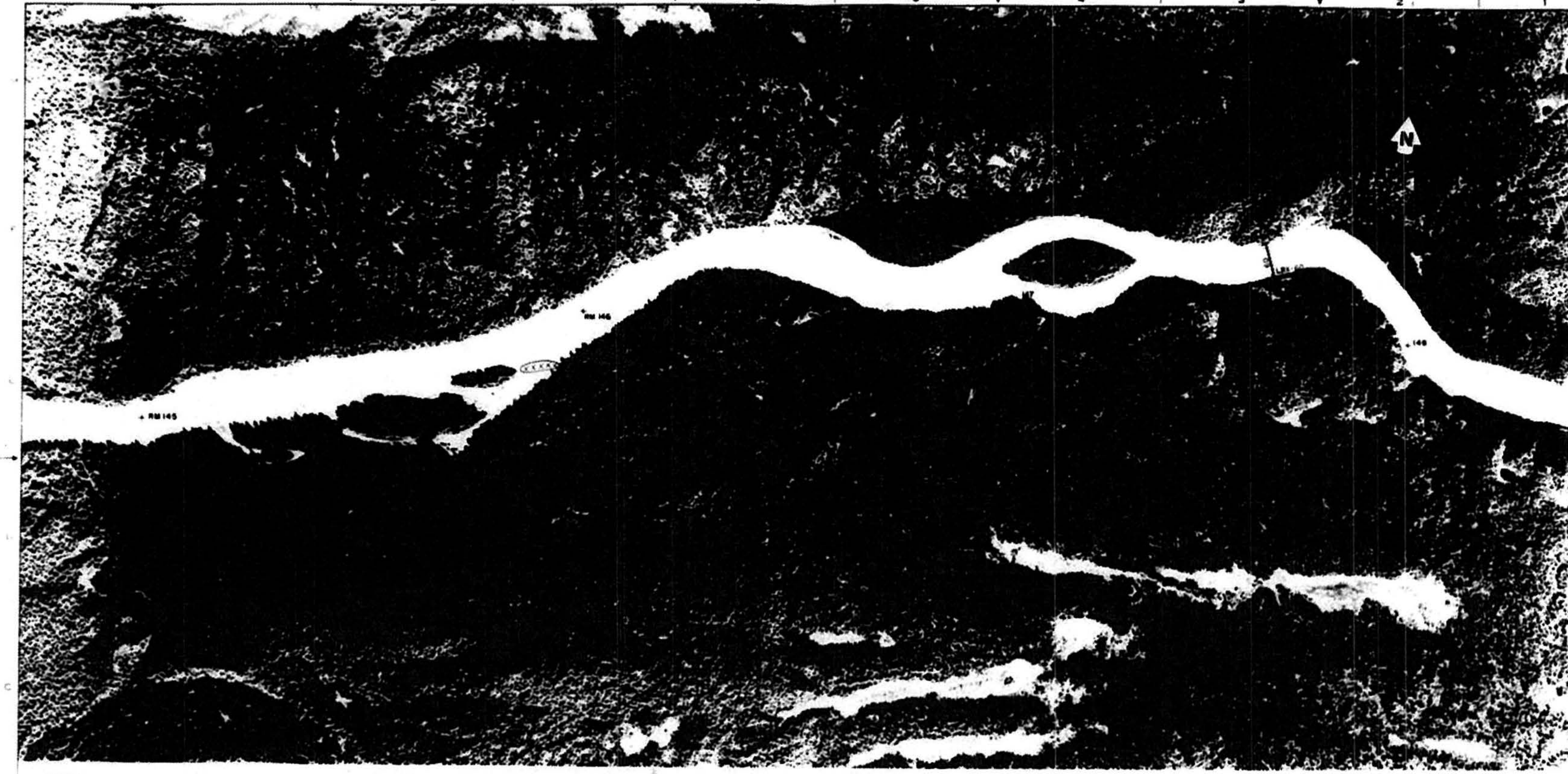
DATE JAN 1981

PROJECT 052216

SHEET 2 OF 31



NOTES

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Berm
△ - STAFF GAGE SITE

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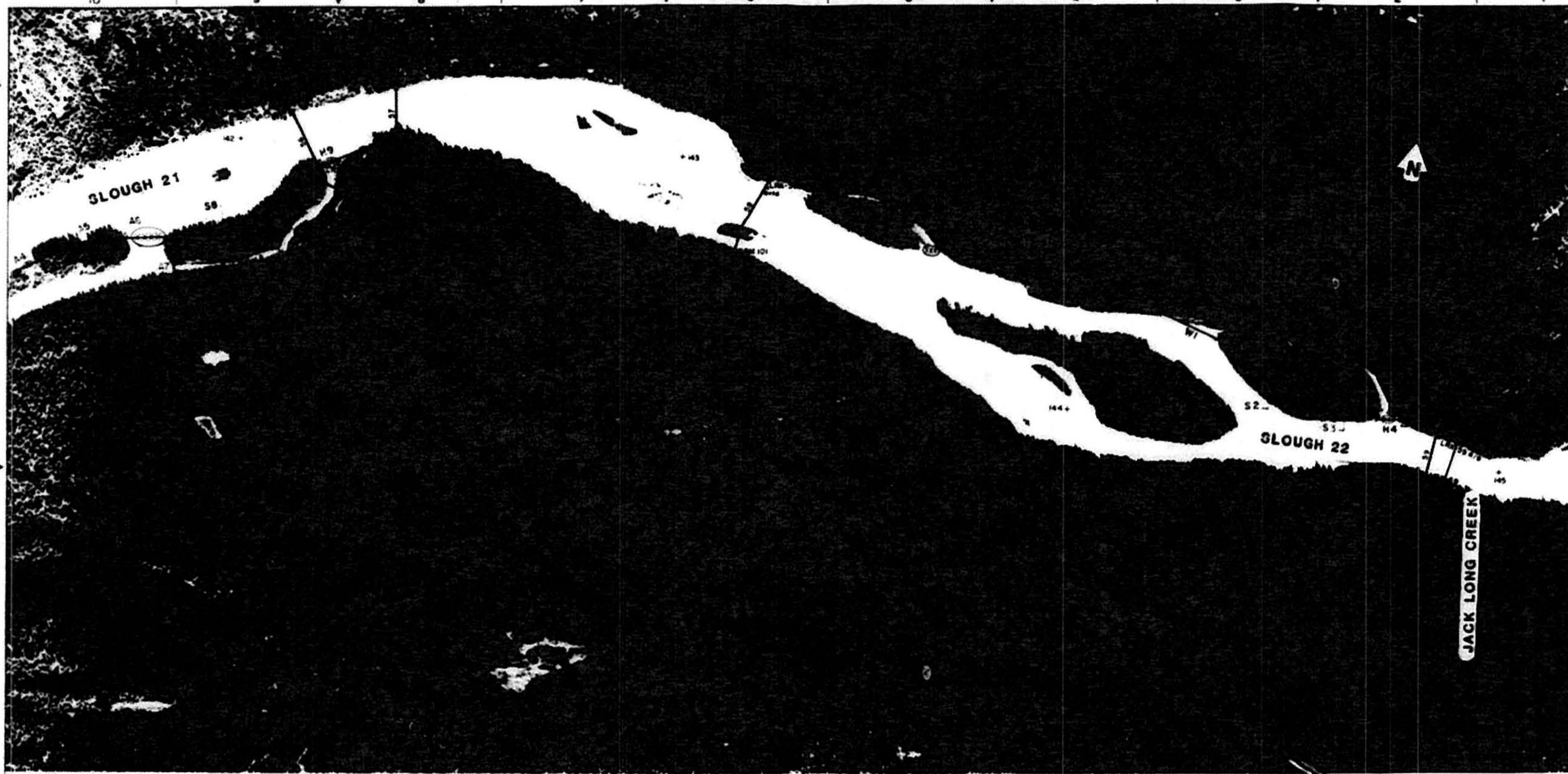

NOTES:

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SCALE 1" = 1000'

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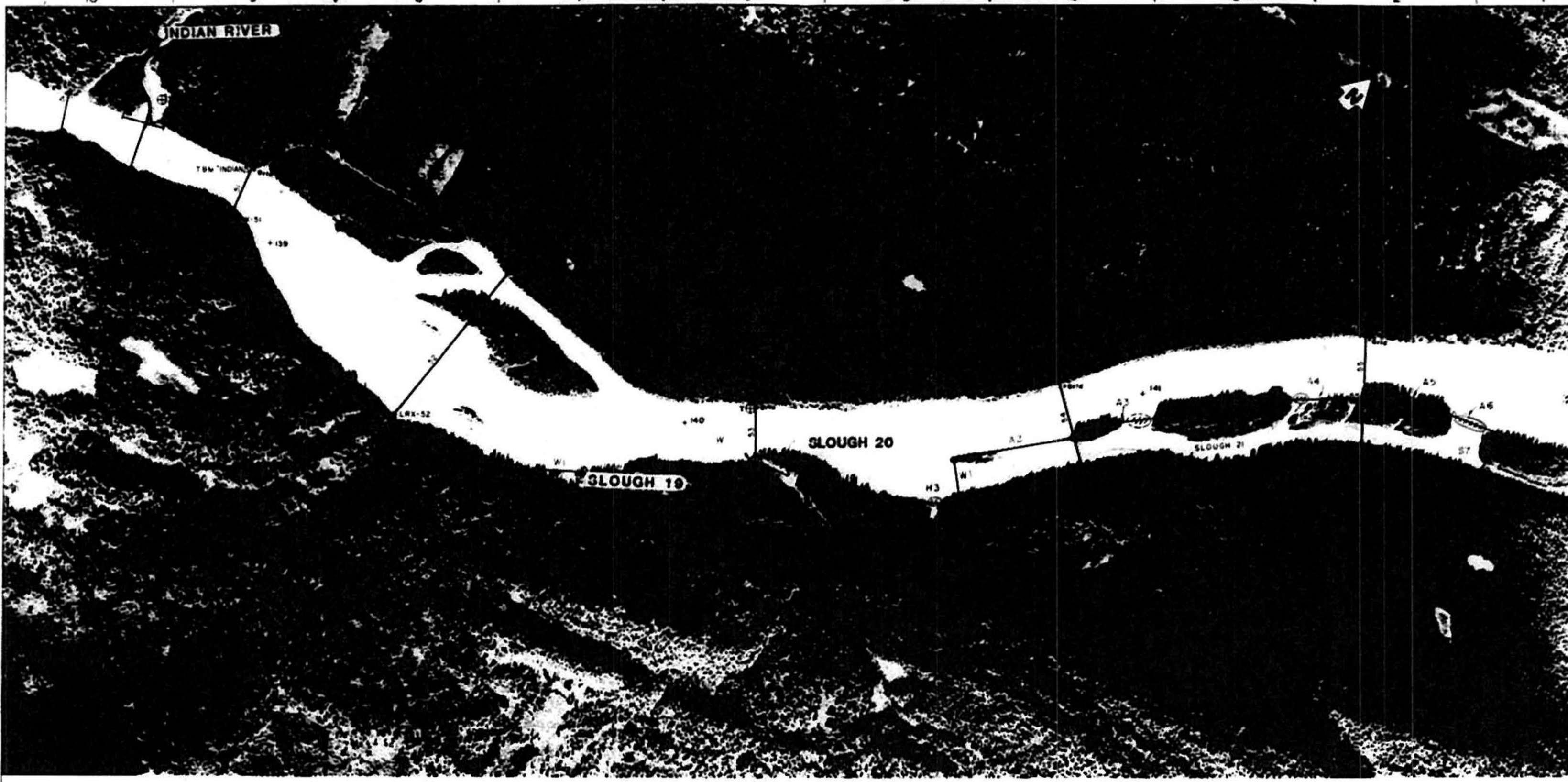

NOTES:

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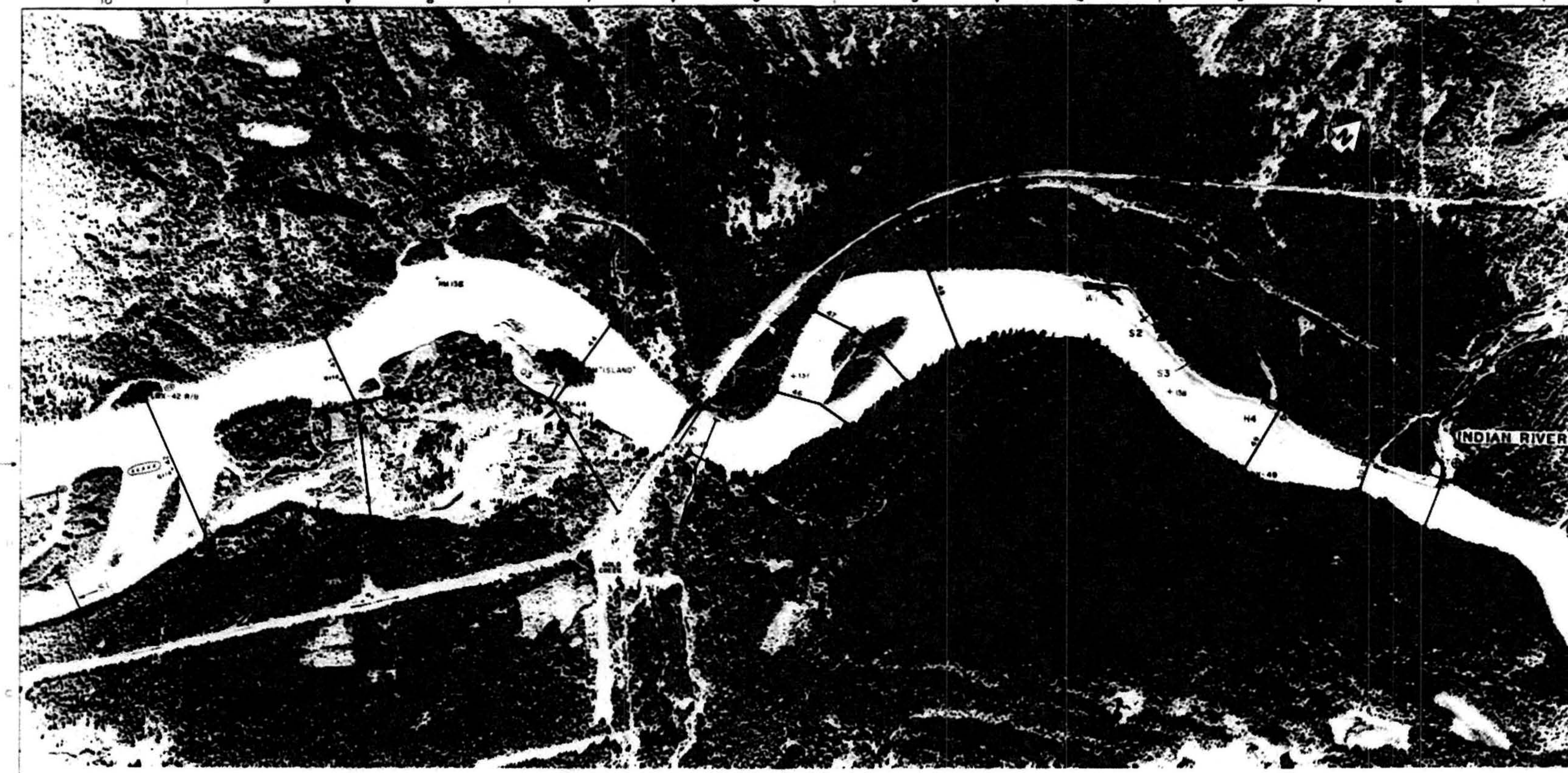

NOTES

1. SOLID LINES DEPICT CROSS SECTION
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3. NUMBERS REFER TO THE LRX DESIGNATION

Berm

STAFF GAGE SITE

STAGE RECORDER

T THERMOGRAPH LOCATION

RIVER MILE

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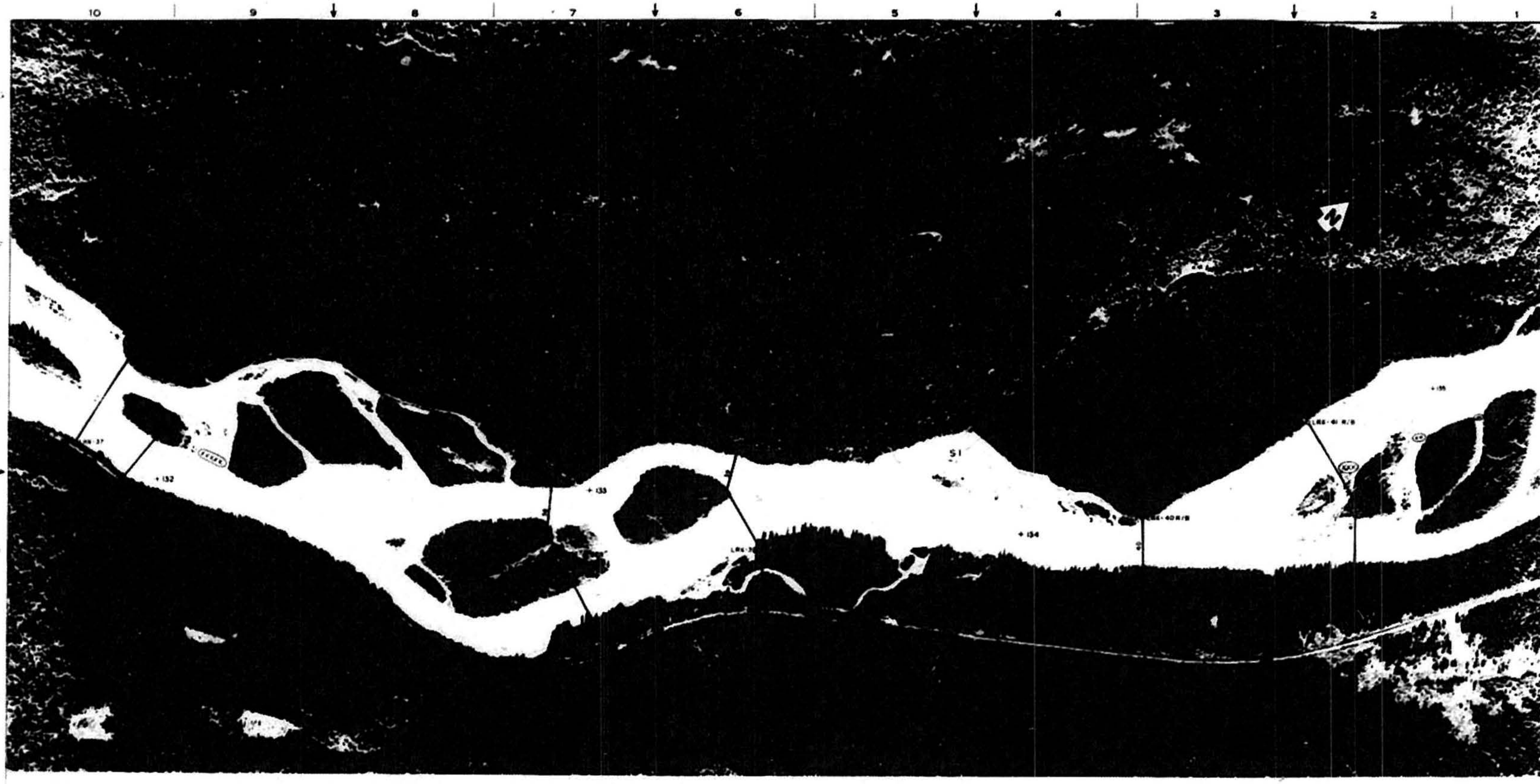

NOTES

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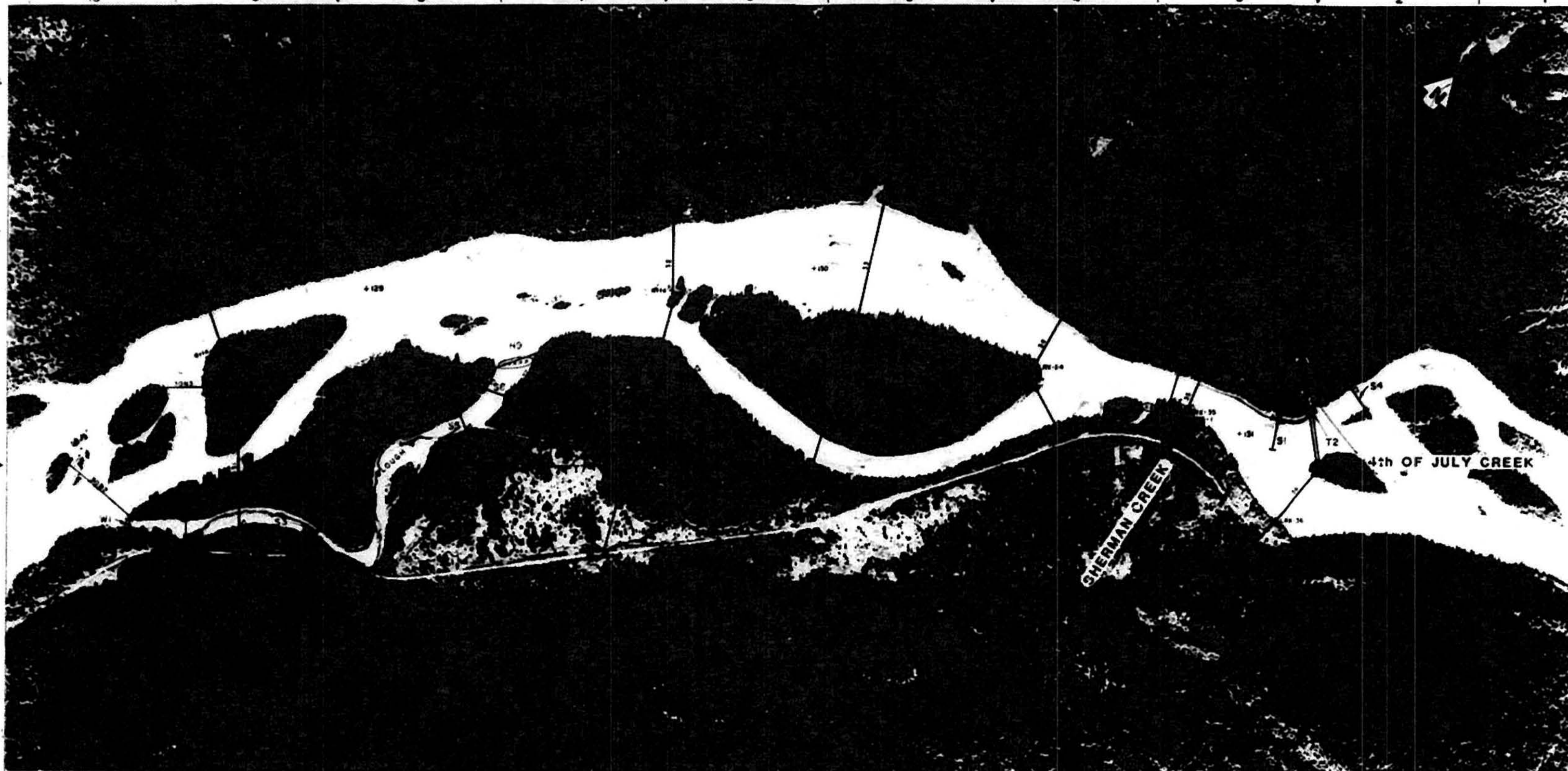

NOTES

1. SOLID LINES REPRESENT CROSS SECTION
2. TEMPORARY BENCHMARKS ARE LOCATED AT EACH END OF EVERY CROSS SECTION
3. NUMBERS REFER TO THE LRX DESIGNATION

Berm
△ STAFF GAGE SITE
▲ STAGE RECORDER
⊕T THERMOGRAPH LOCATION

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SUSITNA RIVER
HYDROGRAPHIC MAPS

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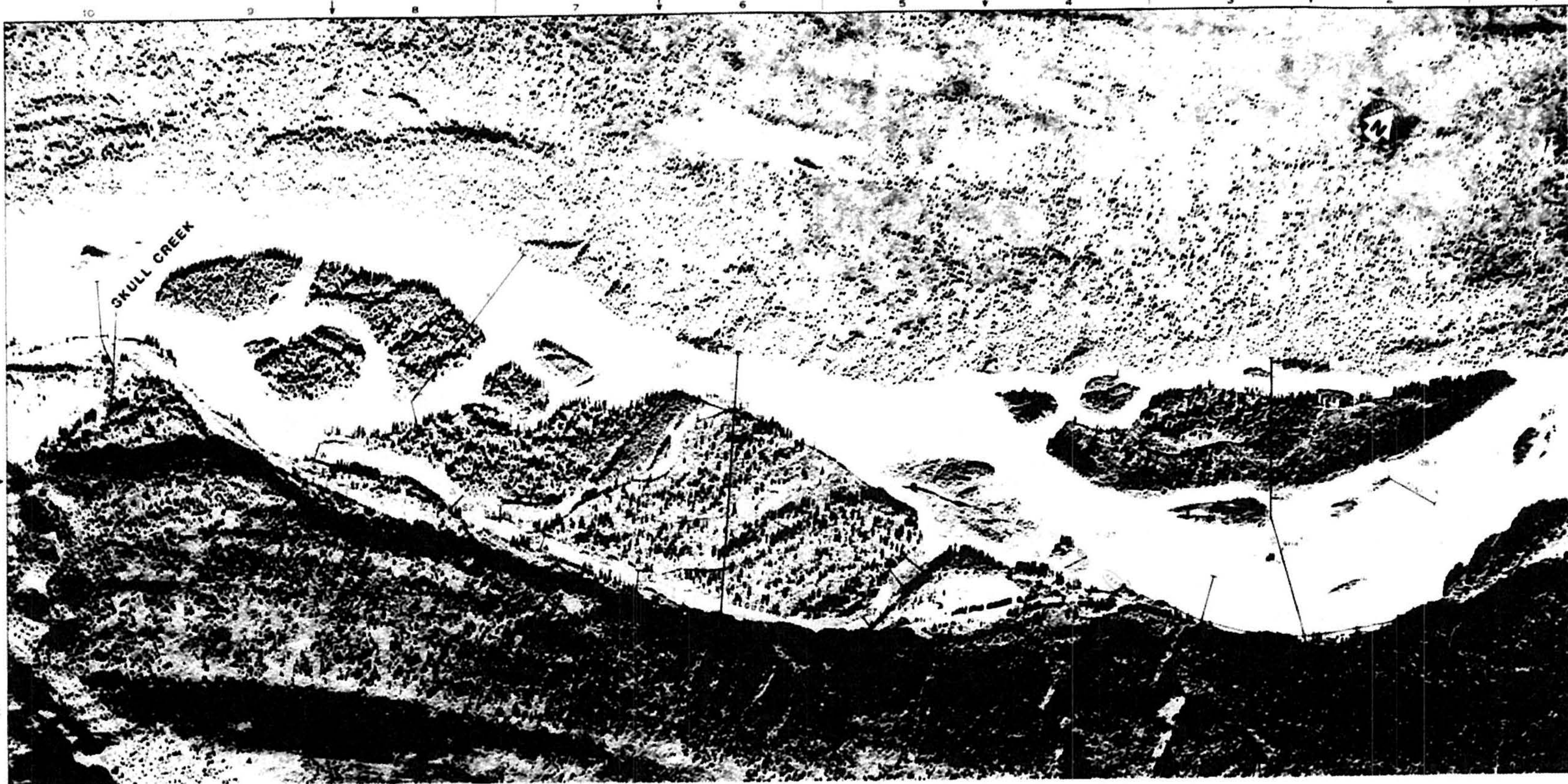

NOTES

1 SOLID LINES DEPICT CROSS SECTION

2 [illegible]

3 [illegible]

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SUSITNA RIVER

HYDROGRAPHIC MAPS

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NOTES

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SUSITNA RIVER
HYDROGRAPHIC MAPS

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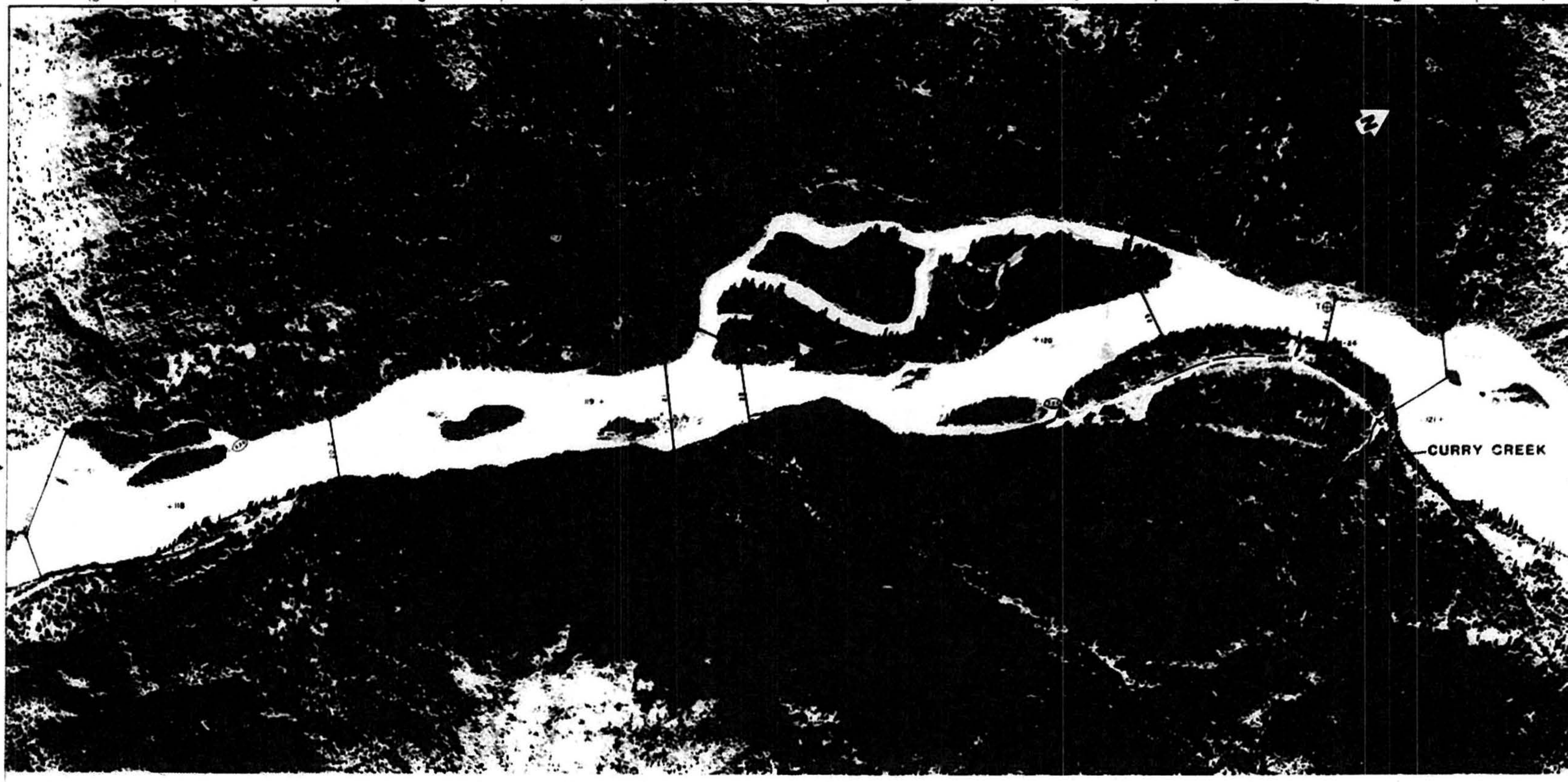

NOTES

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3. NUMBERS REFER TO THE ERX DESIGNATION

STAGE RECORDER

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SUSITNA RIVER

HYDROGRAPHIC MAPS

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DATE JAN 1981

PROJECT 052216

SCALE 1" = 1000'

NOTES

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Berm

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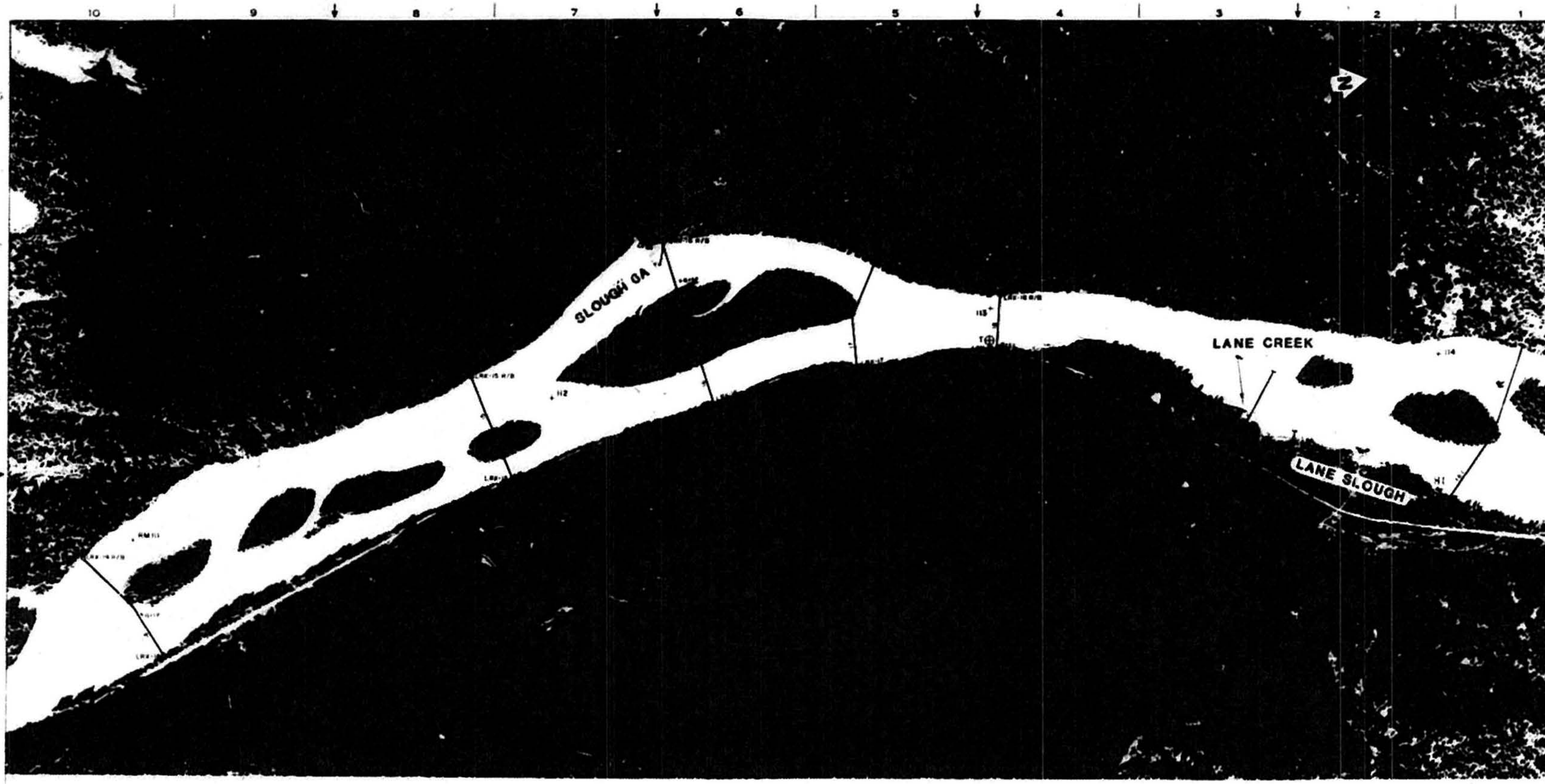

NOTES

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Berm

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NOTES

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DATE	NO.	REVISIONS

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SUSITNA RIVER

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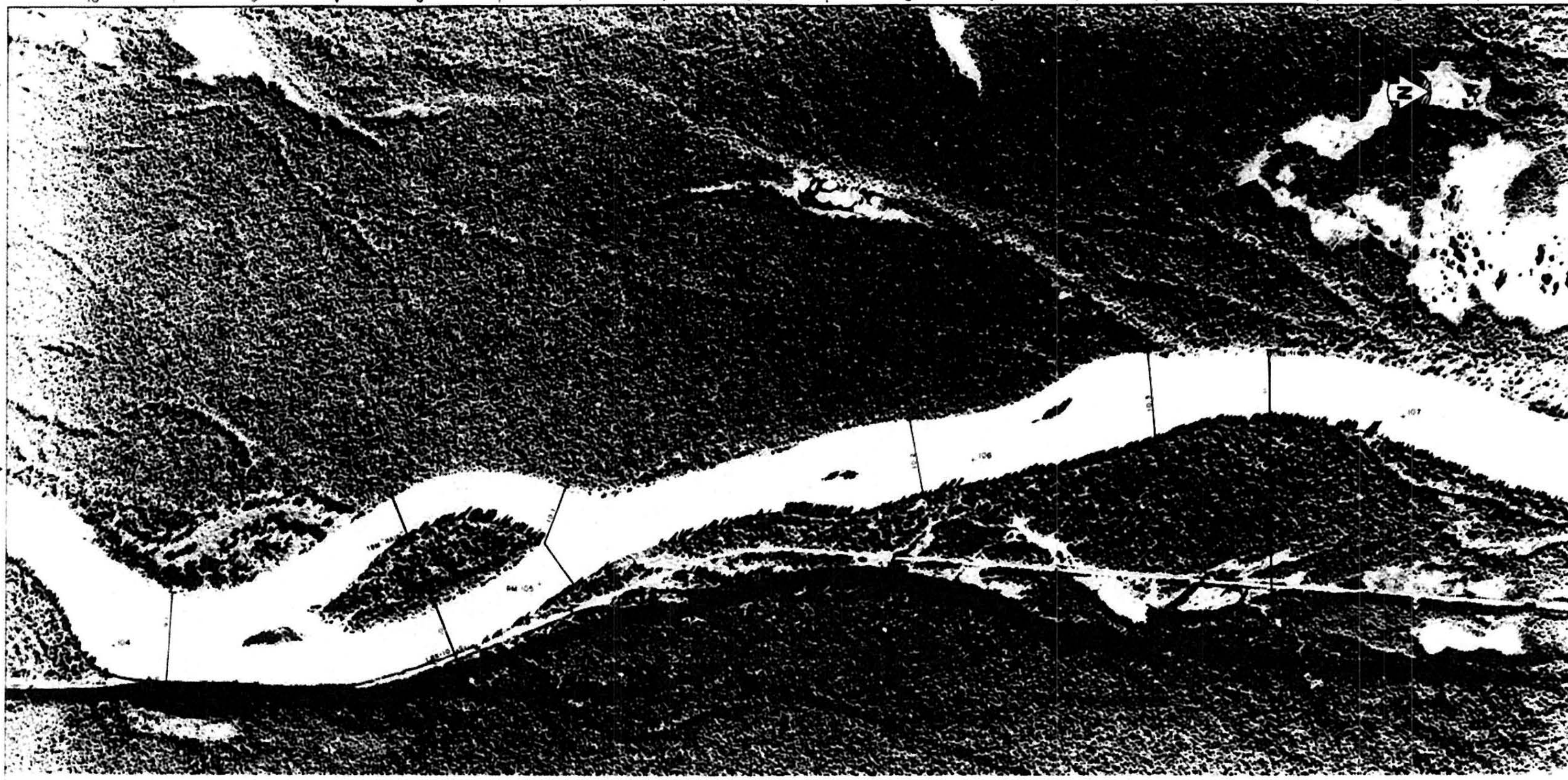
SCALE 1" = 1000'

SHEET 19 OF 37



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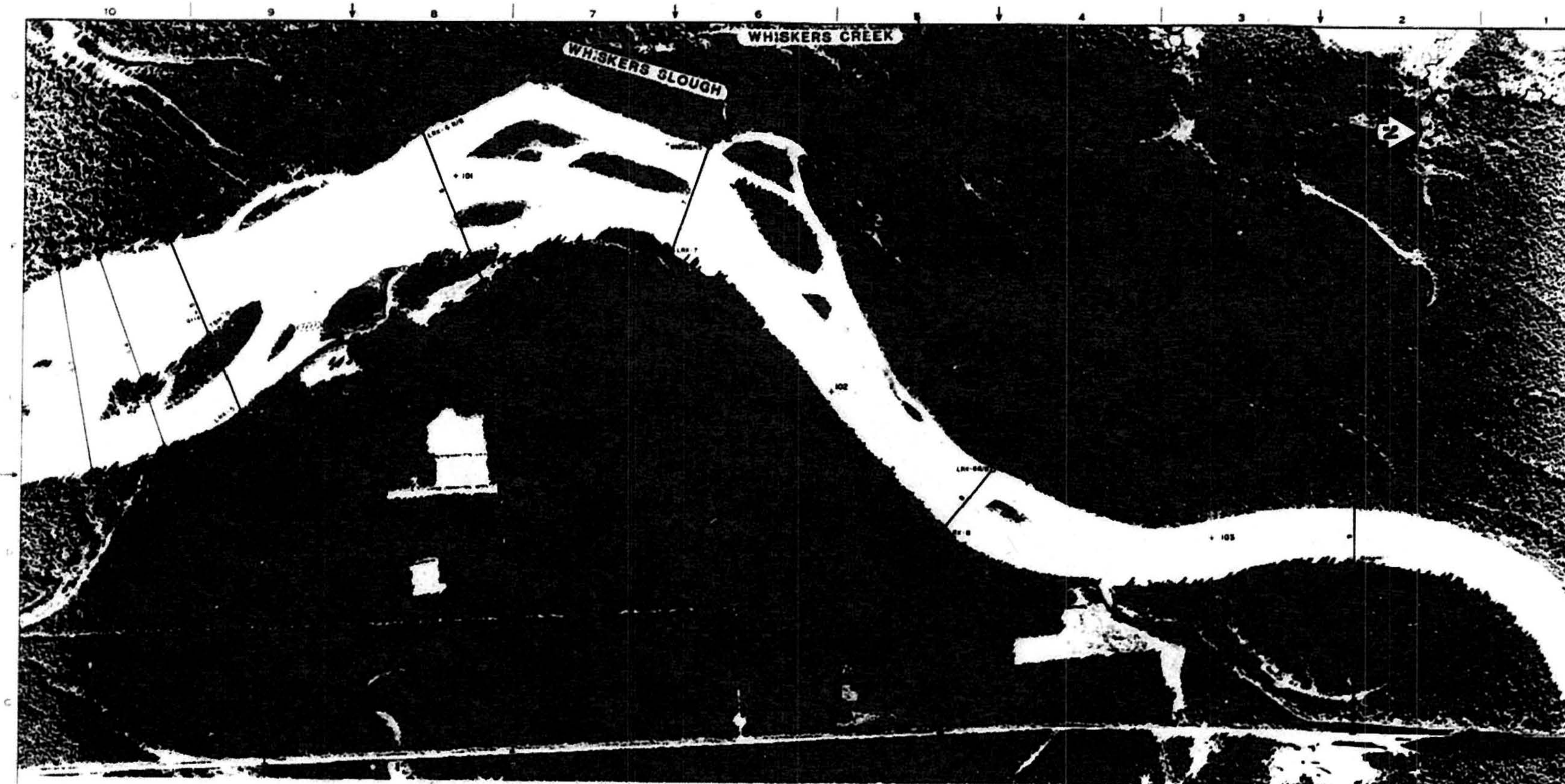

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NUMBERS REFER TO THE LRX DESIGNATION

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SUSITNA RIVER
HYDROGRAPHIC MAP

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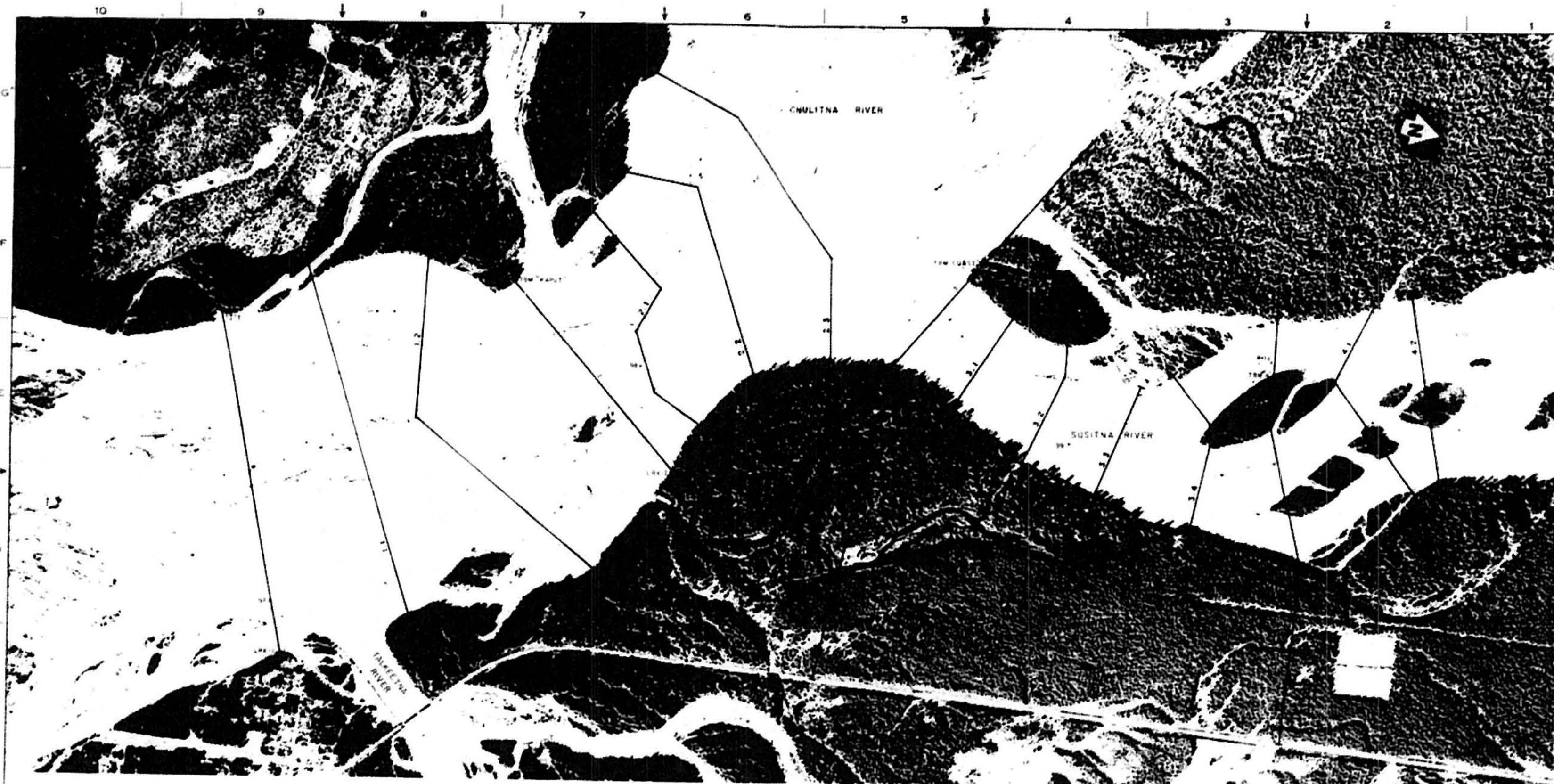
SHEET 16 OF 37



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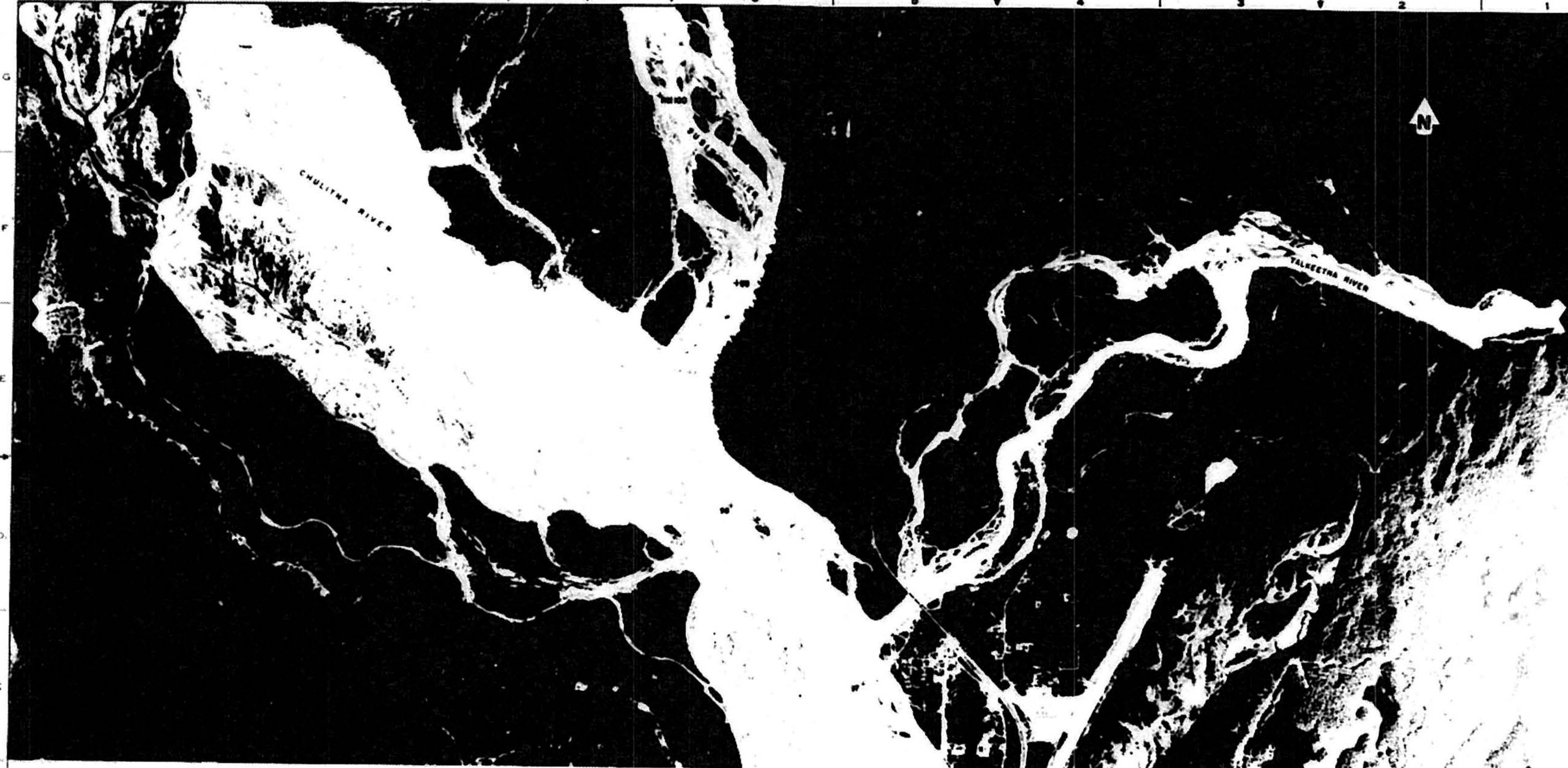

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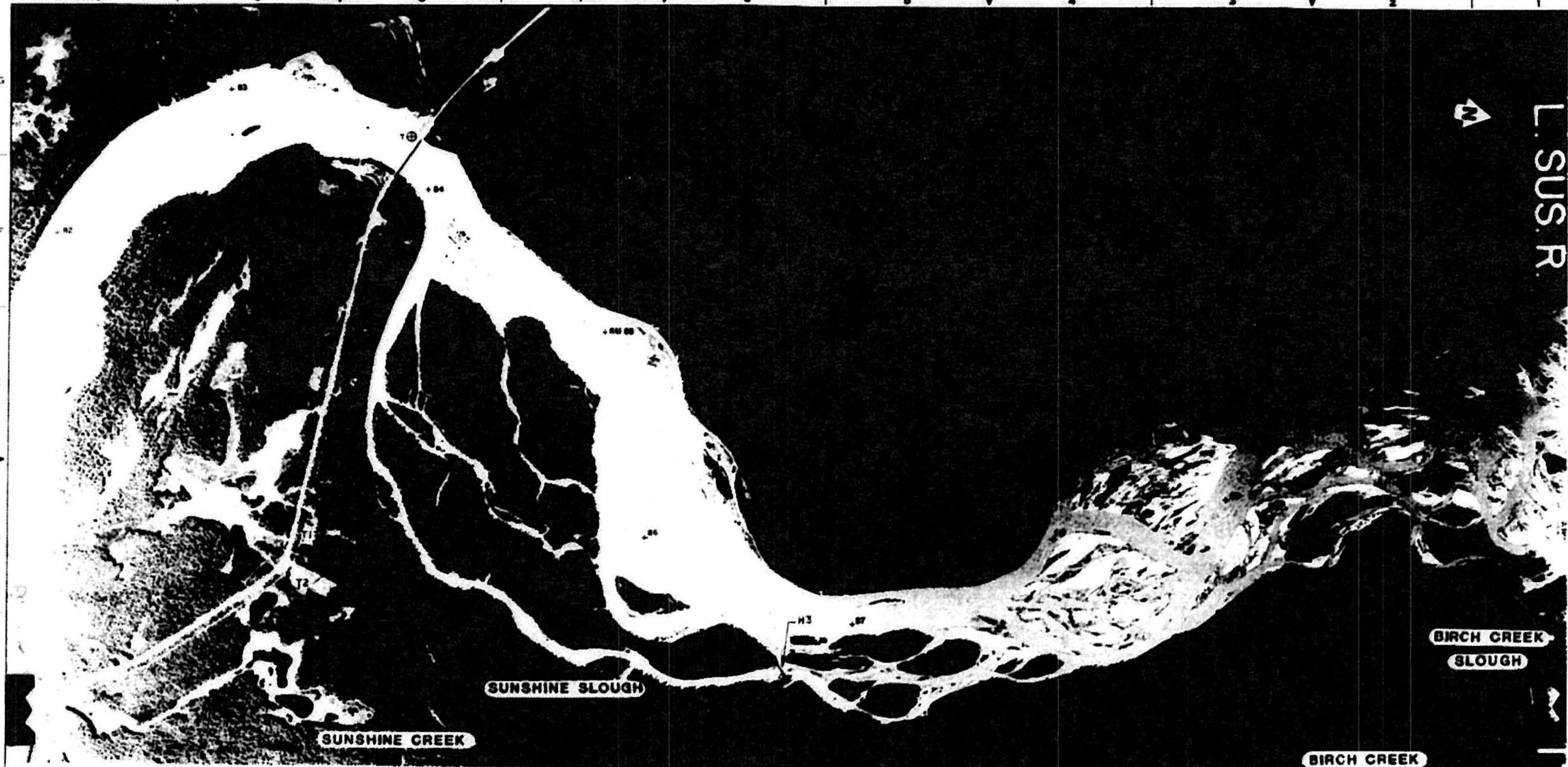

2. TEMPORARY BENCHMARKS ARE LOCATED AT EACH END OF EVERY CROSS SECTION.

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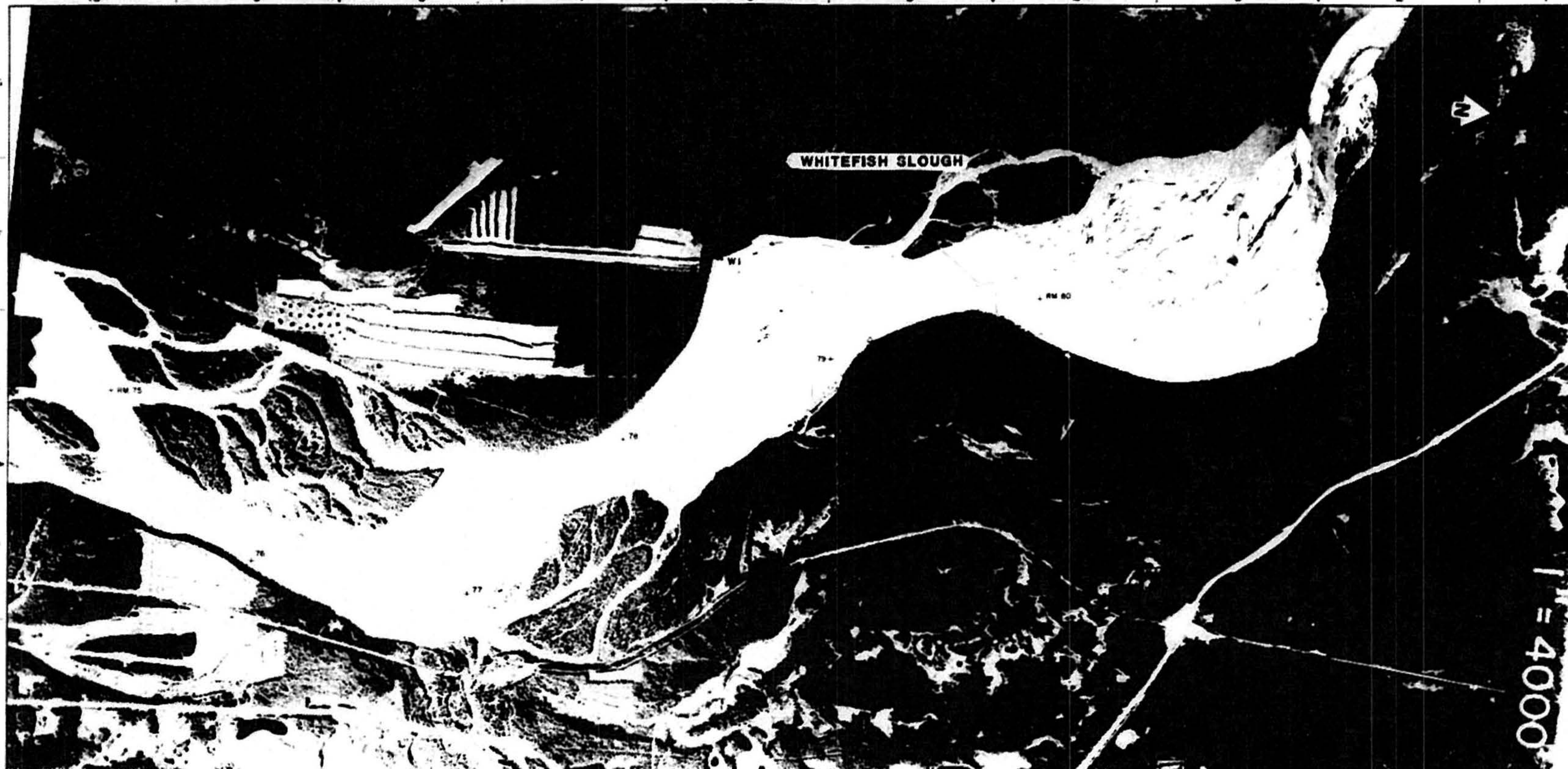
SUSITNA HYDROELECTRIC PROJECT	
SUSITNA RIVER HYDROGRAPHIC MAPS	
R&M	DATE JAN 1981
SCALE 1" = 2000'	PROJECT 052216
SHEET 20 OF 37	



NOTES

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SUSITNA RIVER
HYDROGRAPHIC MAPS

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SCALE 1" = 2000'

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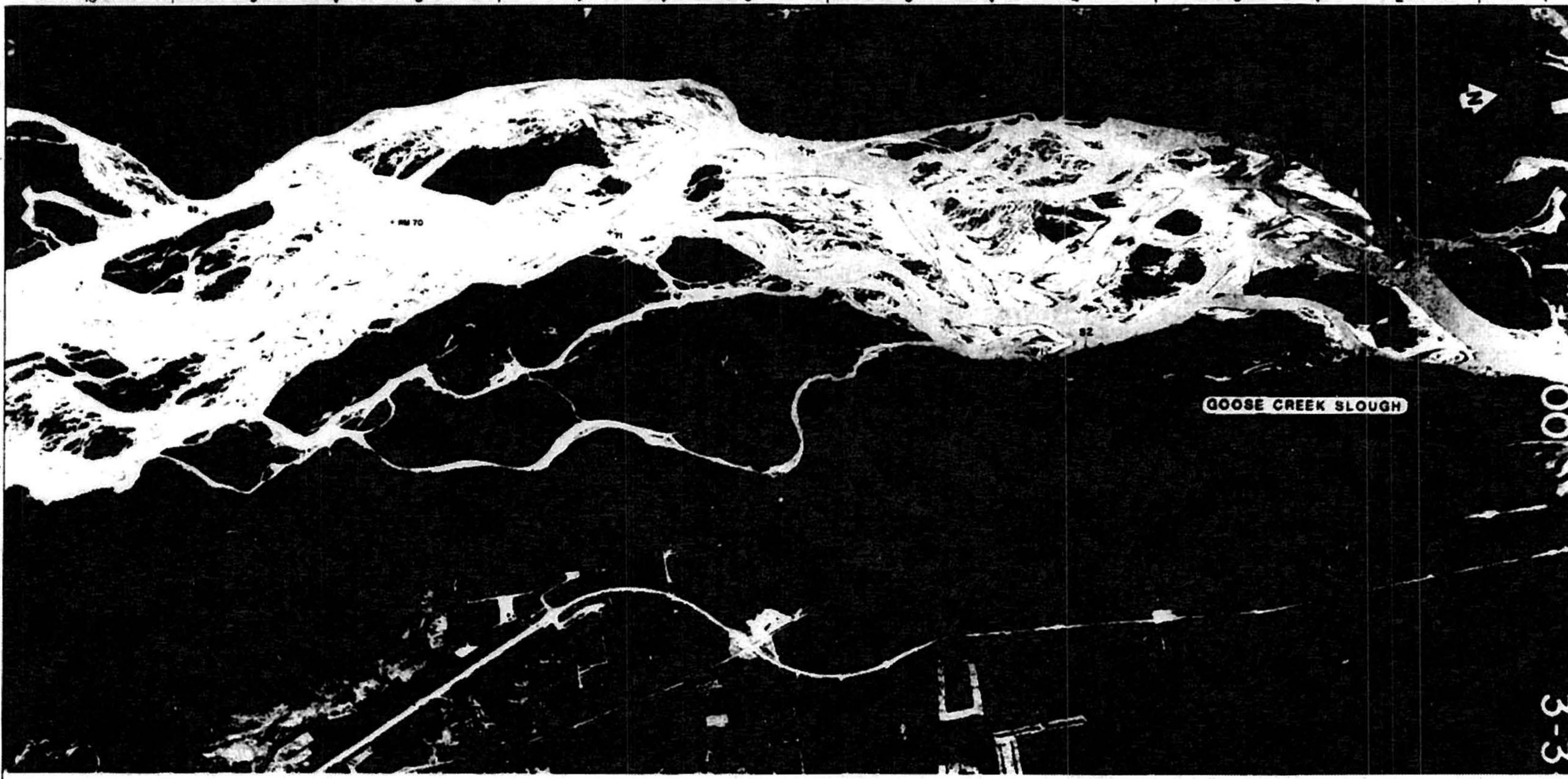

NOTES

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△ - STAFF GAGE SITE
▲ STAGE RECORDER

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SCALE 1"=2000

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