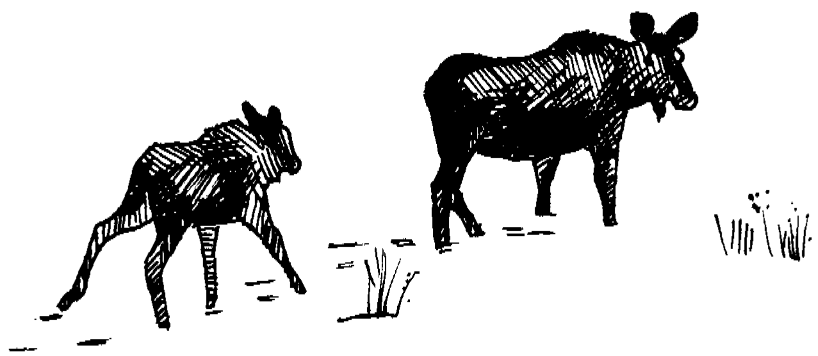
ALASKA DEPARTMENT OF FISH AND GAME

JUNEAU, ALASKA

EFFECTS OF THE TRANS-ALASKA PIPELINE ON MOOSE MOVEMENTS

By Sterling Eide and Sterling Miller



STATE OF ALASKA
Jay S. Hammond, Governor

DIVISION OF GAME
Ronald J. Somerville, Director
Donald McKnight, Research Chief

DEPARTMENT OF FISH AND GAME
Ronald O. Skoog, Commissioner

Final Report
Federal Aid in Wildlife Restoration
Project W-17-10, Job 1.15R

(Printed June 1979)

FINAL REPORT (RESEARCH)

State: Alaska

Cooperators: Sterling Eide and Sterling Miller

Project No .: W-17-10 Project Title: Big Game Investigations

Job No.: 1.15 R Job Title: Effects of the Trans-Alaska Pipeline on Moose Movements

Period Covered: January 1, 1978 to June 30, 1978

SUMMARY

In an attempt to evaluate the effect of the operational Trans-Alaska oil pipeline on moose in the Nelchina Basin, moose encounters with the pipeline as revealed by tracks in the snow were studied. Particular emphasis was placed on the distance from the bottom of the pipe to the top of the pipeline pad (BOP-TOP). Statistical evaluation of these heights as related to moose crossings shows that, although moose do not appear to cross the pipeline randomly, neither do they consistently select for higher pipe except when the pipeline is built at BOP-TOP heights of 5 feet or less.

These results are compared with a similar study conducted during the construction phase of the pipeline in the same area during the preceding two winters and the results are similar.

Other environmental considerations such as sound, snow depths and icicles are discussed. Snowfall for the winter of 1977-78 is compared with historic weather patterns for the area. Snow depths for the winter of 1977-78 were slightly below average.

Data are presented comparing moose sex and age composition counts from areas on either side of the pipeline and the moose population is considered as being stable to increasing during the period of study.

TABLE OF CONTENTS

BACKGROUND

The construction of the Trans-Alaska oil pipeline through important moose (*Alces alces)* habitat of Alaska caused concern that the pipeline might obstruct moose movements between required seasonal habitats. During pipeline construction, an intensive study was conducted to analyze several aspects of this problem (VanBallenberghe 1978). This study was completed in spring 1977; the pipeline became operational in June 1977. A physical description of the pipeline and terminology used to describe the pipeline characteristics were presented by VanBallenberghe (1978).

VanBallenberghe's most intensive study area was on a 29-mile segment of the pipe immediately south of Glennallen, Alaska. In this area he observed a total of 565 successful moose crossings, 53 percent of his total number of crossings. The distance from the bottom of the pipe to the top of the pipeline pad (BOP-TOP height) was defined as a "window" through which moose must pass in order to cross above-ground sections of the pipeline. A comparison of the observed number of crossings through windows of three sizes with the frequency of occurrence of these windows led to VanBallenberghe's conclusion that moose utilized windows between 6 and 8 feet significantly more often than expected, while windows of greater than 8 feet were utilized significantly less than expected ($p < 0.05$). Pipeline windows of less than 6 feet were utilized in proportion to their occurrence. VanBallenberghe also reported on the movements of radio-collared and visually collared moose in the vicinity of the pipeline.

VanBallenberghe reported that the two winters of his study were winters of atypically light snowfall. He recommended a deferred assessment of the impact of snow depth on moose pipeline crossings, and suggested collection of supportive data on impacts of various pipeline characteristics on moose crossing behavior while the pipeline was operational. These characteristics included: window size, snow depth, pipeline noise and ice accumulation on the pipe. Additional data were also needed on moose crossings of the pipeline in different geographical areas.

OBJECTIVES

To determine the effects of various design features of the pipeline on free passage of moose and to evaluate the effects of any restriction of passage on moose populations.

STUDY AREA

The Trans-Alaska Pipeline runs through the Nelchina Basin from the crest of the Alaska Range near Summit Lake to the crest of the Chugach Range near Thompson Pass. Detailed descriptions of this basin and its biotic components are presented by Skoog (1968). Our observations were confined to the Trans-Alaska Pipeline and Pipeline Corridor from Meiers Lake to Squirrel Creek. The pipeline route in this segment generally follows the drainages of the Gulkana and Copper Rivers. In this area the pipeline intersects important moose migratory routes where many animals which spend the summers and fall seasons in the Alphabet Hills and Chugach Mountains migrate across the pipeline and adjacent Richardson Highway to their winter ranges in the lowlands near the Copper River.

The dominant vegetation near the pipeline is a mixture of black spruce (*Picea mariana)*, white spruce (*Picea glauca)*, aspen (*Populus tremuloides)*, balsam poplar *(Populus balsamifera)*, shrub birch *(Betula glanulosa)*, and willow (*Salix* spp.), interspersed with sedge meadows, shallow lakes and riparian habitats. Understories of *Vaccinium* spp., *Ledum*, lichens, and mosses are prevalent. The terrain in the study area is gently sloping except where rivers and creeks have cut steep banks through the rolling hills.

The moose population in the Nelchina Basin is heavily hunted by both local residents and by residents from the larger communities of Anchorage and Fairbanks. Game Management Unit 13, encompassing the entire study area, produces a reported harvest of 700 to 1,000 bull moose annually--more than any other Game Management Unit in the State (Alaska Dept. of Fish and Game, unpubl. data). Results of annual sex and age composition surveys of moose populations in count areas near the study area (Table 1), indicate moose populations were stable or increasing at the time this study was conducted.

The 90-mile segment of the pipeline studied was subdivided into three sections, each capable of being traversed by truck or snow machine in a single day's travel. Each section was characterized by some differences in habitat type, moose usage and pipeline characteristics.

Section 1 was a 29.4-mile segment from Glennallen south to Squirrel Creek. Ninety-four percent of the pipeline in this section was elevated above ground. This section corresponded with the "Glennallen" area studied by VanBallenberghe and consisted of Pipeline Alignment Sheet Numbers

Table 1. Composition count data for the Alphabet Hills and upper Gakona River areas, 1973-1978.

	Alphabet Hills				Upper Gakona River			
Year	Bulls per 100 cows	Calves per 100 cows	Moose per hour	Total Sample	Bulls per 100 cows	Calves per 100 cows	Moose per hour	Total Sample
1973	20.5	17.5	46	608	21.2	14.1	53	211
1974	22.6	26.6	36	903	31.5	21.3	59	136
1975	19.3	10.5	48	667	12.9	26.9	48	130
1976	27.9	19.5	52	780	22.2	21.3	48	155
1977	25.6	34.0	40	917	25.3	22.7	62	228
1978	28.9	22.8	46	933	28.4	25.0	81	227

16 through 21. It was bordered on the east by the Copper River and on the west by the Chugach Mountain Range. On its south end a large burn provided important winter food for moose. A few moose which had been collared in the Alphabet Hills to the northwest were known to winter in this area. It is likely that most of the moose present in Section 1 during the winter spent the summer in the Chugach Mountains.

Section 2 was a 38.4-mile segment from Glennallen north to Sourdough. This section corresponded with Pipeline Alignment Sheets 22 through 27. Here the terrain is virtually flat and soil types and permafrost characteristics required that the pipeline be constructed above ground except for four sag bends, a special refrigerated burial, and a highway crossing. Eighty-six percent of the pipeline in this segment is elevated above ground. Most moose crossings (533) were recorded along this section.

Section 3 was a 21.1-mile segment from Hogan Hill north to Meiers Lake. It included Pipeline Alignment Sheets 28 through 31. In this section, elevations are higher and the terrain becomes more uneven. Snow depths were greatest in this section. Because of the better soil drainage in Section 3 the pipeline was buried for 38 percent of its extent in this section. VanBallenberghe (1978) described the area near Haggard Creek and Hogan Hill as being important migratory routes for tagged moose from the Alphabet Hills.

PROCEDURES

Field measurements

Each of the three sections of the pipeline was surveyed, in rotation, a total of 15 times in winter 1978. The surveys were conducted by truck or snowmachine and, occasionally, by foot. Surveys were conducted when snow conditions were appropriate for recording tracks on the pipeline pad. For each set of moose tracks encountered on the pipeline pad, the following data were collected on standardized forms:

1. Location - Alignment Sheet (AS) Number and Vertical Support Member (VSM) number.
2. Whether the tracks indicated a crossing of, or a deflection from, the pipe.
3. Measured distance from the bottom of the pipe to the top of the pad (BOP-TOP height) at all above-ground encounters with the pipe.
4. Whether the encounter was at a Designated Big Game Crossing (DBGC).
5. Whether the encounter occurred at a buried section of the pipe.
6. Whether calf moose were present.
7. Direction of travel.
8. Date.
9. Depth of snow under the pipe, away from the pipe where it was not influenced by the pipeline or adjacent roadway, and the height of any snow berm.
10. Comments on various additional environmental or construction features of the pipeline at the encounter (pipeline noise, formation of icicles, etc.).

In addition to these data, a schematic drawing was made of each moose encounter, as indicated by its tracks.

Data analysis

These data were keypunched and sorted utilizing the SPSS (Special Package for the Social Sciences) program on the University of Alaska's Honeywell computer.

Data on the frequency of occurrence of pipeline windows of various sizes (BOP-TOP) were obtained to permit a comparison of this frequency with the frequency of measured BOP-TOP heights at which moose encountered the pipeline. The pipeline height for each approximately 60-foot segment was calculated to be the average of the BOP-TOP heights of the VSM's on each end of the segment. BOP-TOP heights at the VSM were derived from a list of all heights published by the Alyeska Pipeline Company (Listing of AS-Redesigned VSM Construction Section 1 & 2. April 20, 1977). The proportion of the pipeline which was buried was determined from these published Alyeska data and direct measurements. For above-ground pipe, the data on pipeline heights were grouped in two ways for statistical analyses: 1) in 1-foot intervals with heights less than 5 feet as well as heights greater than 13 feet lumped together and 2) in the three categories utilized by VanBallenberghe (less than 6 feet, 6 to 8 feet, and greater than 8 feet).

Chi square tests were run on these data to determine whether the pipeline characteristics where moose crossed the pipe differed from the proportion of these characteristics actually present. Characteristics evaluated were buried or above-ground pipeline and window size for the above-ground pipeline. The data were further analyzed to determine which cells of the chi square test contributed to rejection of the null hypothesis; this technique was described by Neu et. al. (1974) and utilized by VanBallenberghe (1978).

The influence of snow depth (under the pipe, away from the pipe, and snow berm) on the measured BOP-TOP heights of moose crossings was also analyzed. Correlation coefficients between these two variables were calculated by the SPSS computer package, SCATTERGRAM.

All tests were conducted on the total 90-mile segment of the pipeline studied as well as on each of the three sections, described previously, of the total segment. The analysis by section was done to identify any inconsistencies between sections in the selection of pipeline characteristics at which moose chose to cross; if the same selectivity patterns did not appear in each of the three sections, there would be reason to question the validity of the pattern.

RESULTS

Relationships with window size

The proportion of above-ground pipe with windows of various sizes as well as the proportion of the pipeline which is buried are presented in Table 2. A total of 10 categories were utilized to compare frequency of occurrence of various window sizes with frequency of crossing through windows of these same sizes. Some lumping of categories was occasionally necessary to assure that expected values for the chi square test exceeded five animals for each category. The numbers of moose crossing through windows of the sizes given in Table 2 as well as the number of crossings at buried segments are presented in Table 3.

Chi square tests to determine whether the proportion of BOP-TOP window sizes or proportion of buried segments at which moose chose to cross differed significantly from the proportion at which these same windows or buried sections occurred, were significant ($p < 0.005$). This was true for the entire length of the pipe studied as well as for each of the three pipeline sections along this length (Table 4). These results suggest that the pattern at which moose cross the pipeline through windows of various sizes or across buried sections of pipe is not random, selectivity is indicated.

Similar tests were run for moose crossings of above-ground versus buried segments of the pipe. The number of crossings at above-ground segments of the pipe differed significantly ($p < 0.005$) from the expected values based on the frequency of occurrence of above-ground and buried segments (Table 5). The observed number of crossings at buried segments was less than the expected values for Sections 2 and 3, and for all sections lumped. The observed number of crossings at buried segments was greater than that expected in Section 1. Certain designated big game crossings were buried to facilitate moose and caribou (*Rangifer tarandus*) passage across the pipeline; these were called sag bends. Neither the frequency of sag bends nor the number of observed crossings at sag bends were considered adequate to statistically test selectivity for sag bends by moose.

In order to determine if selectivity for windows of various sizes occurred, similar tests were run on above-ground segments of the pipe only (Table 6). In all cases, a significant variation was observed between the numbers of moose crossing through windows of various sizes and the frequency of occurrence of windows of these sizes ($p < 0.005$).

The level of significance of these tests suggested that moose were highly selective in their choice of pipeline crossing sites; the pipeline is not crossed randomly. In order to determine whether this selectivity is based on pipeline characteristics (e.g. window size), additional analysis was needed. Neu et. al. (1974) developed a technique which can be utilized when the null hypothesis of the chi square test is rejected, as in this case. This technique permits determination of which cells of the analysis are significantly contributing to the rejection of the null hypothesis. VanBallenberghe (1978) utilized this technique in the analysis of pipeline crossing data for moose. It would be expected that if the non-random pattern of moose crossings shown above was a result of pipeline characteristics, the same pattern would be evident in different sections of the pipe and that significant variations would be in the same direction (observed less than expected or vice versa). This analytical technique was utilized for the observed distribution of window sizes of above-ground pipe.

Table 2. Number of 60' pipeline segments in one foot BOP-TOP height categories in each of the 3 pipeline sections.

	Section 1		Section 2		Section 3		Total	
	No.	%	No.	%	No.	%	No.	%
Buried	155	6.0	472	14.0	768	37.8	1,395	17.4
1' - 4.99'	75	2.9	80	2.4	14	0.7	169	2.1
5' - 5.99'	461	17.8	411	12.2	71	3.5	943	11.8
6' - 6.99'	789	30.5	782	23.1	213	10.5	1,784	22.3
7' - 7.99'	522	20.2	779	23.0	361	17.8	1,662	20.8
8' - 8.99'	263	10.2	494	14.6	265	13.0	1,022	12.8
9' - 9.99'	155	6.0	192	5.7	195	9.6	542	6.8
10' - 10.99'	71	2.7	88	2.6	93	4.6	252	3.1
11' - 11.99'	37	1.4	38	1.1	19	0.9	94	1.2
12' - 12.99'	25	1.0	27	0.8	10	0.5	62	0.8
13+	35	1.4	18	0.5	24	1.2	77	1.0
Total	2,588	100	3,381	100	2,033	100	8,002	100

Table 3. Number of moose crossing the pipeline through windows of various sizes and across buried segments.

	Section 1 No.	Section 2 No.	Section 3 No.	Total No.
Buried	40	21	61	119
1' - 4.99'	4	3	1	8
5' - 5.99'	40	106	26	172
6' - 6.99'	74	153	69	296
7' - 7.99'	75	121	70	266
8' - 8.99'	41	46	89	176
9' - 9.99'	31	45	47	123
10' - 10.99'	6	27	37	70
11' - 11.99'	1	8	5	14
12' - 12.99'	0	0	0	0
13+	3	3	5	11
Total	315	533	410	1,255

Table 4. Value of Chi square to test the null hypothesis that moose cross above ground segments of the pipe (in 1' increments) and buried segments of the pipe in proportion to the frequency of occurrence of these segments.

	Section 1 No.	Section 2 No.	Section 3 No.	Total No.
Chi square	54.4	111.9	125.9	113.6
Degrees of freedom	8*	8*	7**	10
p	<.005	<.005	<.005	<.005

* Data lumped for crossings through windows greater than 11'.

** One foot increments from 6-11 feet, data lumped for crossings between 0.1 and 6' and for crossings greater than 11'.

Table 5. Values of Chi square to test the null hypothesis that moose cross above ground and buried segments of the pipe in proportion to the frequency of occurrence of above ground and buried segments.

	Section 1	Section 2	Section 3	Total
Chi square	25.1	44.5	91.8	54.4
Degrees of freedom	1	1	1	1
p	<.005	<.005	<.005	<.005

Table 6. Values of Chi square to test the null hypothesis that moose cross above ground segments of the pipe through windows (in one foot increments) in proportion to the frequency of occurrence of these windows.

	Section 1	Section 2	Section 3	Total
Chi square	31.8	60.4	21.8	55.8
Degrees of freedom	7*	7*	6**	9***
p	<.005	<.005	<.005	<.005

* Crossings through all windows greater than 11 feet are lumped.

** Crossings through all windows of .1 - 6 feet are lumped as are crossings through windows greater than 11 feet lumped.

*** Crossings through all windows greater than 12 feet lumped.

For the total length of the pipeline studied (Table 7), pipe windows of less than 5 feet and windows greater than 12 feet were utilized significantly less than expected ($p < 0.05$ and $p < 0.10$, respectively). Pipe windows of 9 - 9.9 and 10 - 10.9 feet were utilized significantly more than expected ($p < 0.10$ and $p < 0.10$, respectively). No other pipe categories were utilized significantly more or less than expected ($p < 0.20$). The observed and expected values for the total length of the pipeline studies, expressed as percentages, are illustrated in Fig. 1.

In Section 1, window sizes greater than 11 feet were utilized significantly less than expected ($p < 0.05$) while sizes of 9 - 9.99 feet were utilized significantly more than expected ($p < 0.20$) (Table 8). No other window sizes differed significantly from the expected ($p < 0.20$). The observed and expected values for Section 1, expressed as percentages, are illustrated in Fig. 2.

In Section 2, windows of less than 5 feet and windows of 8 - 8.99 feet were utilized significantly less than expected ($p < 0.05$) (Table 9). Windows of 5 - 5.9 feet were utilized significantly more than expected ($p < 0.05$). No other windows were utilized significantly more or less than expected ($p < 0.20$). The observed and expected values for Section 2, expressed as percentages, are illustrated in Fig. 3.

In Section 3, windows of 7 - 7.9 feet were utilized significantly less than expected ($p < 0.05$) and the utilization of other window sizes did not differ significantly from expected values ($p < 0.20$) (Table 10). The observed and expected values in Section 3 are illustrated in Fig. 4.

A summary of the window sizes of above-ground pipe utilized significantly more or less than expected, and their corresponding (p) values, are given in Table 11. As can be seen from inspection of Table 11 and Figs. 1-4, there is a tendency for moose to select for windows of intermediate sizes (9-10.99 feet) and a tendency to avoid exceptionally small (less than 5 feet) and large (12 or more feet) windows, however this tendency is not consistently present in all of the individual sections of the pipe--in some cases the relationships of observed to expected are reversed between different sections of the pipe. These results suggest that factors other than, or in addition to, window size influence the non-random pattern of above ground pipeline crossings by moose. The most probable additional influences include:

1. Adherence to traditional crossing areas by individual moose regardless of pipeline characteristics.
2. Habitat types adjacent to crossing locations.

Other Environmental Factors

Snow depths

A comparison of snow depths with height of pipe selected by moose was made during this study. This was done to determine whether the effective decline in window size caused by snow accumulation would result in a shift toward increased frequency of crossing through larger

Table 7. Confidence intervals for proportions of moose expected to cross above to ground segments of the pipeline through each of nine window sizes. Expected values are based on the proportion of the pipeline with windows of each size. Data are for the entire 90 mile pipeline segment studied. Analysis follows the technique of Neu et al (1974).

Pipe Height (feet)	Proportion of Total Pipeline Segment	Observed # Crossings	Expected # Crossings	Proportion Observed in Each Interval	Confidence Interval, alpha =		
					.05	.10	.20
1 - 4.99	.026	8	29	.007	0 - .015*	.0001 - .014*	.007 - .013*
5 - 5.99	.143	172	162	.151	.119 - .183	.122 - .180	.124 - .178
6 - 6.99	.270	296	307	.261	.222 - .300	.225 - .297	.228 - .294
7 - 7.99	.252	266	286	.234	.197 - .272	.199 - .267	.202 - .266
8 - 8.99	.155	176	176	.155	.133 - .187	.125 - .135	.128 - .182
9 - 9.99	.082	123	93	.108	.081 - .135	.083 - .134*	.085 - .131*
10 - 10.99	.038	70	43	.062	.041 - .084*	.042 - .082*	.044 - .080*
11 - 11.99	.014	14	16	.012	.002 - .022	.003 - .021	.004 - .020
12+	.021	11	24	.010	.001 - .019	.002 - .015*	.002 - .018*
TOTALS	1.00	1136	1136	1.00			

* Observed proportion significantly different from the expected proportion at indicated alpha level

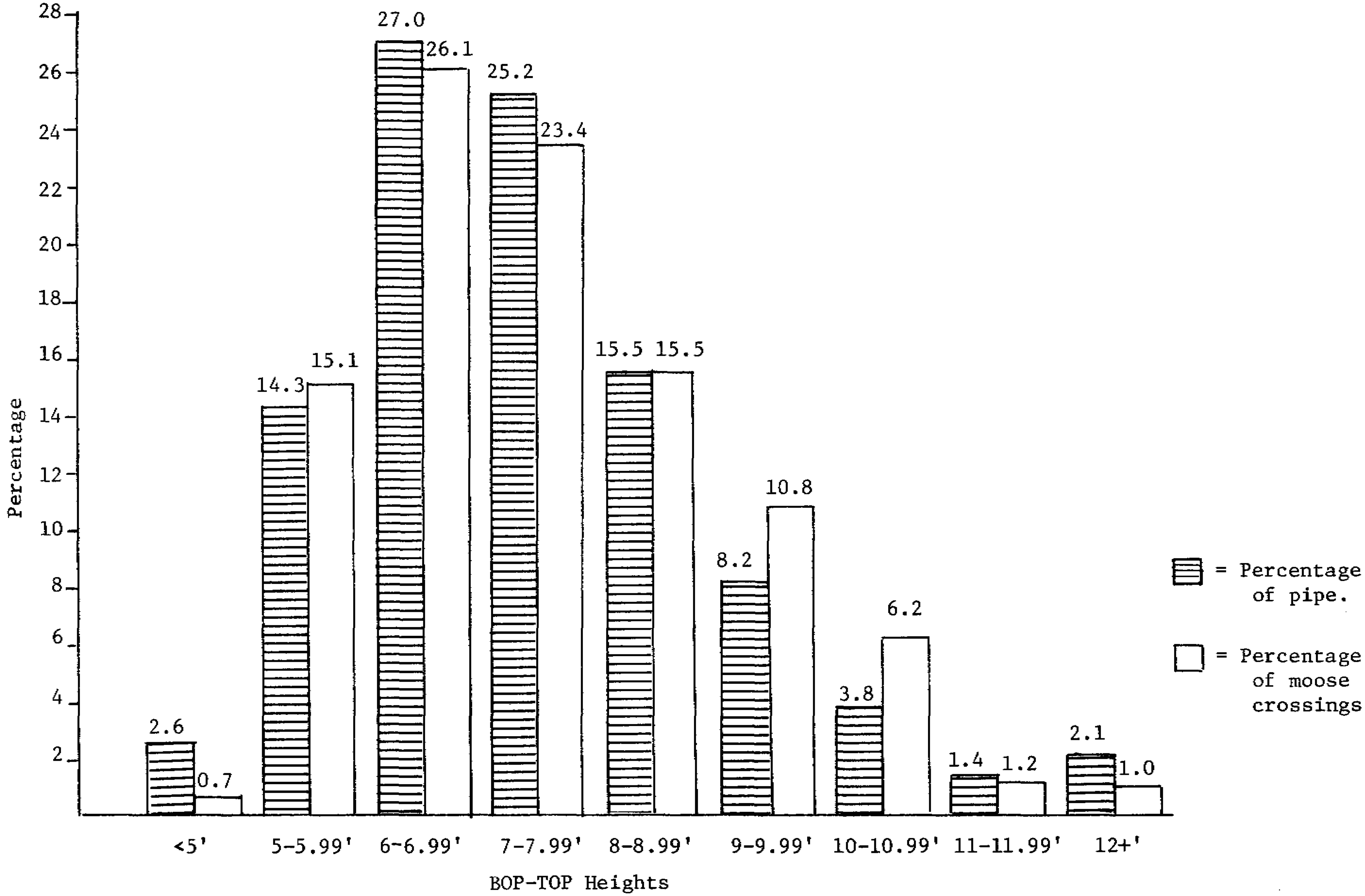


Figure 1. Percentage of moose crossings at various pipe heights and percentage of pipe present at these heights for entire study area.

Table 8. Confidence intervals for proportions of moose expected to cross above ground segments of the pipeline through each of eight window sizes. Expected values are based on the proportion of the pipeline with windows of each size. Data are for pipeline segment 1, Glennallen south to Squirrel Creek. Analysis follows the technique of Neu et al (1974)

Pipe Height (feet)	Proportion of Total Pipeline Segment	Observed # Crossings	Expected # Crossings	Proportion Observed in Each Interval	Confidence Interval, alpha = .05	Confidence Interval, alpha = .20
1 - 4.99	.0308	4	9	.0145	0 - .036	0 - .033
5 - 5.99	.1895	40	52	.1455	.083 - .208	.092 - .199
6 - 6.99	.3243	74	89	.2691	.190 - .348	.203 - .336
7 - 7.99	.2145	75	59	.2727	.193 - .352	.206 - .340
8 - 8.99	.1081	41	30	.1491	.086 - .213	.096 - .203
9 - 9.99	.0637	31	18	.1127	.056 - .169	.065 - .160*
10 - 10.99	.0292	6	8	.0218	0 - .048	0 - .044
11+	.0399	4	11	.0145	0 - .036	0 - .033*
TOTALS	1.00	275	276	1.00		

* Observed proportion significantly different from the expected proportion at indicated alpha level

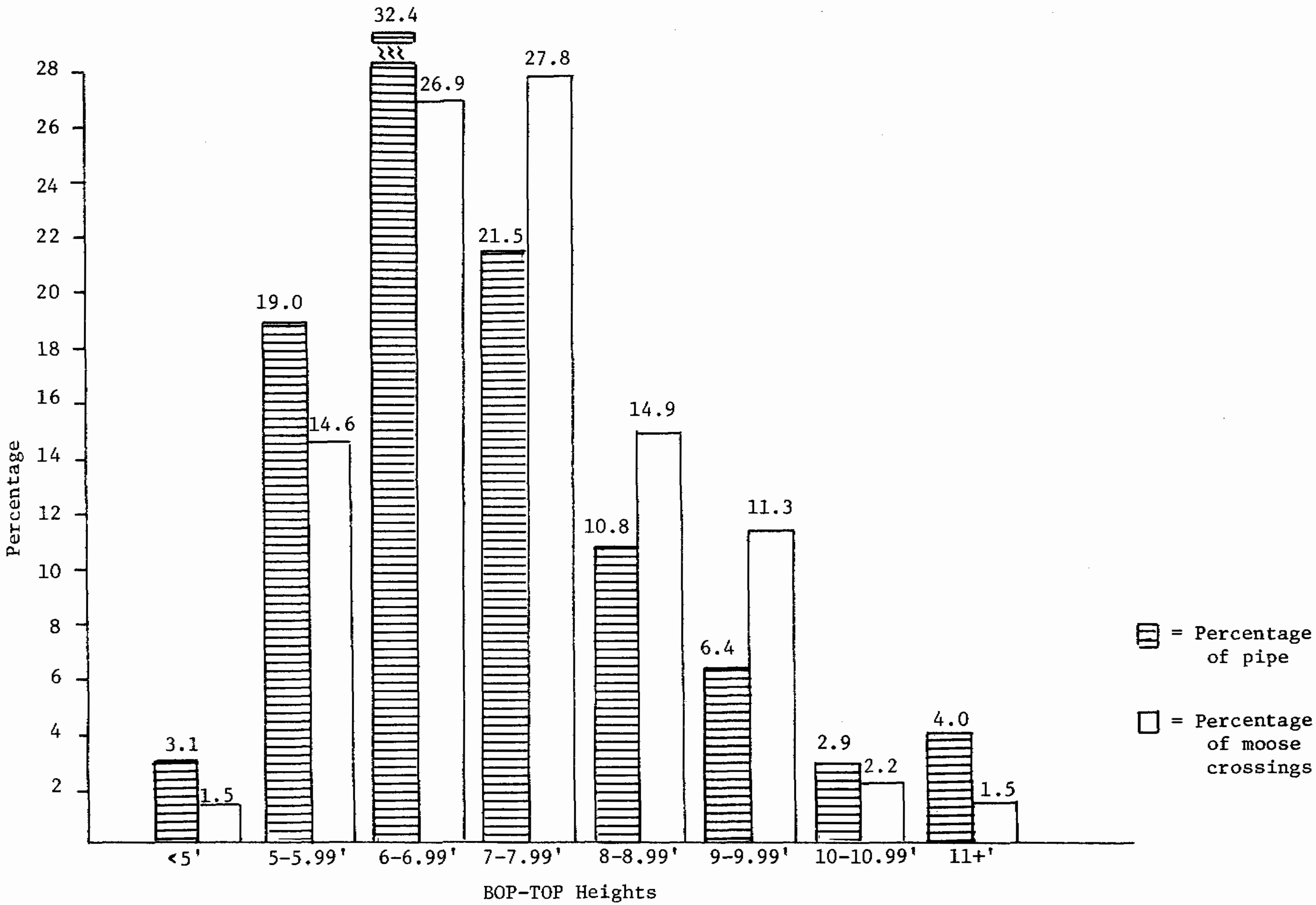


Figure 2. Percentage of moose crossings at various pipe heights and percentage of pipe present at these heights for Area 1.

Table 9. Confidence intervals for proportions of moose expected to cross above ground segments of the pipeline through each or eight window sizes. Expected values are based on the proportion of the pipeline with windows of each size. Data are for pipeline segment 2, Glennallen north to Sourdough. Analysis follows the technique of Neu et al (1974).

Pipe Height (feet)	Proportion of Total Pipeline Segment	Observed # Crossings	Expected # Crossings	Proportion Observed in Each Interval	Confidence Interval, alpha = .05	.20
1 - 4.99	.0275	3	14	.0059	0 - .016*	0 - .014*
5 - 5.99	.1413	106	72	.2070	.154 - .260*	.162 - .252*
6 - 6.99	.2688	153	138	.2988	.239 - .358	.248 - .349
7 - 7.99	.2678	121	137	.2363	.181 - .292	.189 - .283
8 - 8.99	.1698	46	87	.0898	.053 - .127*	.058 - .121*
9 - 9.99	.066	45	34	.0879	.051 - .125	.057 - .119
10 - 10.99	.0303	27	16	.0527	.046 - .082	.028 - .077
11+	.0285	11	15	.0215	.003 - .041	.006 - .038
TOTALS	1.00	512	513	1.00		

* Observed proportion significantly different from the expected proportion at indicated alpha level

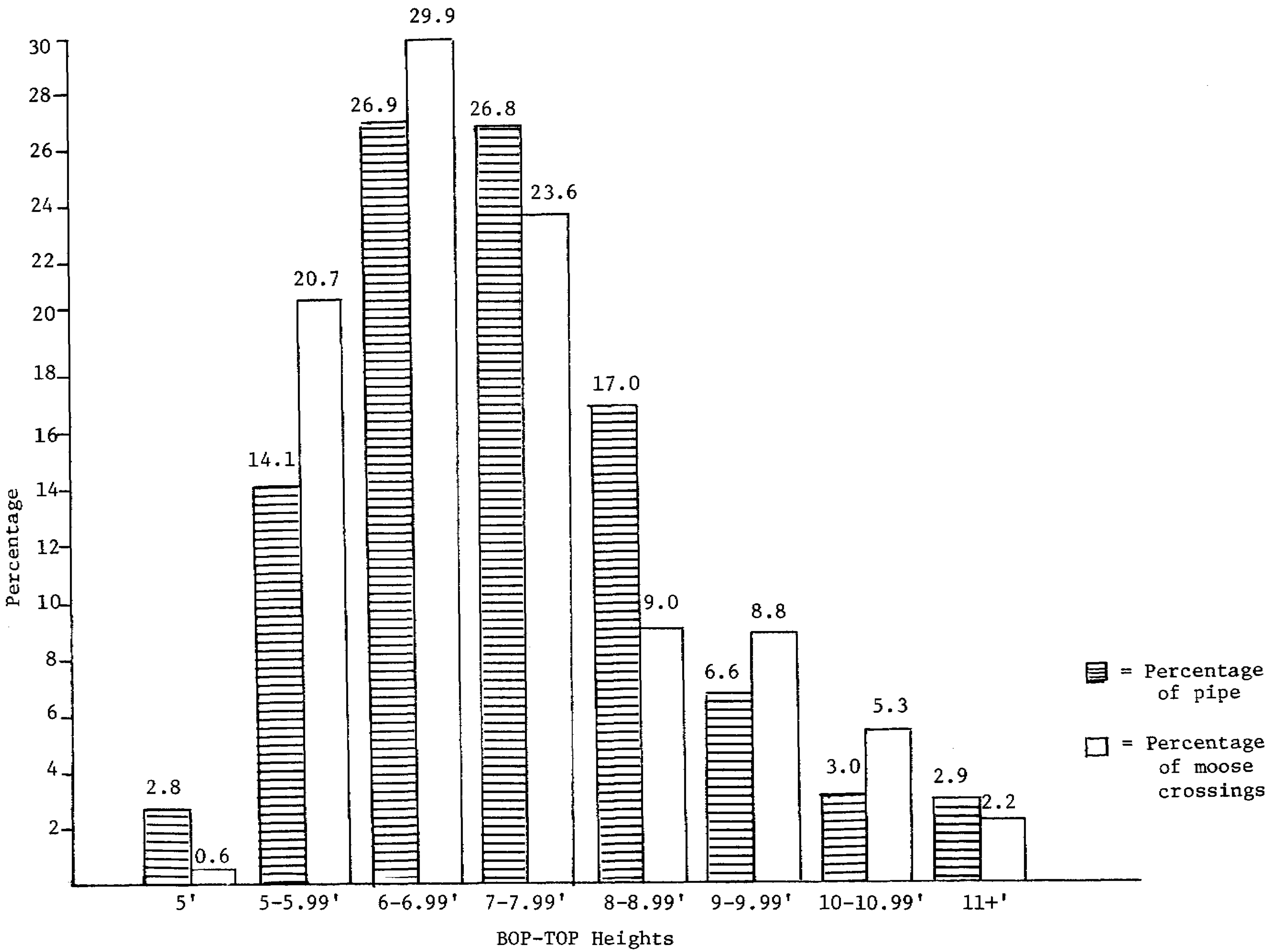


Figure 3. Percentage of moose crossings at various pipe heights and percentages of pipe present at these heights for Area 2.

Table 10. Confidence intervals for proportions of moose expected to cross above ground segments of the pipeline through each of seven window sizes. Expected values are based on the proportion of the pipe with windows of each size. Data are for pipeline segment 3, Hogan Hill north to Miers Lake. Analysis follows the technique of Neu et al (1974)

Pipe Height (feet)	Proportion of Total Pipeline Segement	Observed # Crossings	Expected # Crossings	Proportion Observed in Each Interval	Confidence Interval, alpha = .05	Confidence Interval, alpha = .20
1 - 5.99	.0672	27	23	.0774	.036 - .119	.042 - .112
6 - 6.99	.1684	69	59	.1977	.136 - .260	.146 - .250
7 - 7.99	.2854	70	100	.2006	.138 - .263*	.149 - .253*
8 - 8.99	.2095	89	73	.2550	.187 - .323	.198 - .312
9 - 9.99	.1542	47	54	.1347	.081 - .188	.090 - .170
10 - 10.99	.0735	37	26	.1060	.058 - .154	.006 - .146
11+	.0419	10	15	.0287	.003 - .055	.007 - .051
TOTALS	1.00	349	350	1.00		

* Observed proportion significantly different from the expected proportion at indicated alpha level.

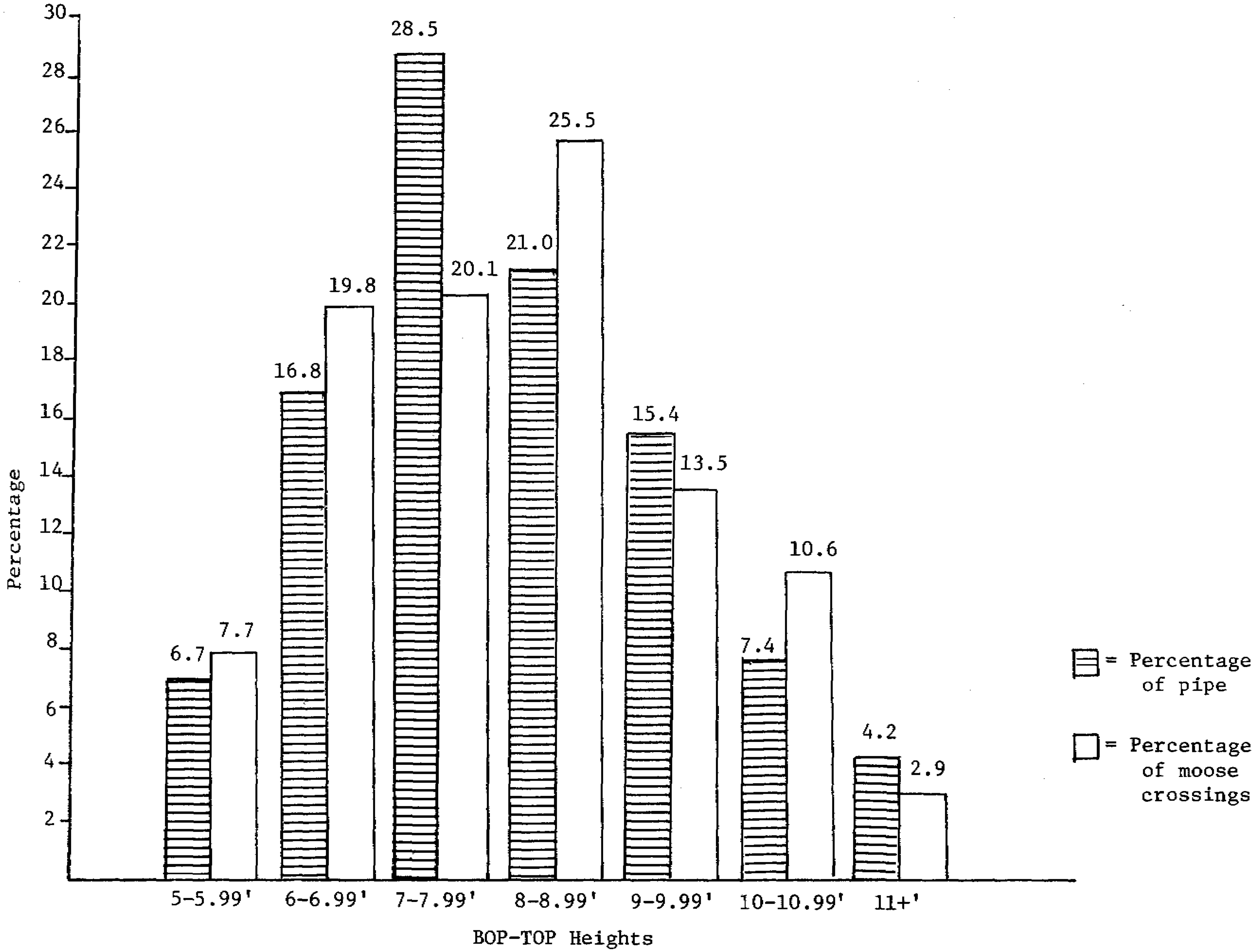


Figure 4. Percentage of moose crossings at various pipe heights and percentage of pipe present at these heights for Area 3.

Table 11. Level of significance for pipeline windows utilized significantly more and less than expected by moose crossing above ground portion of the pipeline.

UTILIZED SIGNIFICANTLY MORE THAN EXPECTED

Window size category (feet)	Section 1	Section 2	Section 3	Total
5 - 5.99		($p < .05$)		
9 - 9.99	($p < .20$)			($p < .10$)
10 - 10.99				($p < .05$)

UTILIZED SIGNIFICANTLY LESS THAN EXPECTED

Window size category (feet)	Section 1	Section 2	Section 3	Total
1 - 5		($p < .05$)		($p < .05$)
7 - 7.99			($p < .05$)	
8 - 8.99		($p < .05$)		
11+	($p < .05$)			
12+				($p < .10$)

windows. During the study period, snow depths never exceeded 26 inches away from the pipe or 20 inches under the pipe. At these depths, there was no correlation between pipe heights selected by moose and snow depths under the pipe or on the ground near the pipe.

A comparison of snow depths at Gulkana Airport as reported by the National Oceanic and Atmospheric Administration was made with snow depths recorded during this study at moose crossing locations on a nearby 6-mile segment of the pipeline (AS-22) (Fig. 5). These comparisons and other measurements taken during this study showed that snow depths under the pipeline were generally less than those reported on the ground near the pipeline. This is caused by snowfall accumulating on the pipeline rather than falling on the ground below the pipeline. Wind conditions which cause snow drifting can modify this relationship. During this study we did not observe snow depths under the pipe to exceed those on the nearby pad. Table 12 shows snow depths at Gulkana during this study in relation to previous years of snowfall. The 1977-78 winter, when this study was conducted, was near the median for winter severity (snow depth) in the last 35 years.

An additional environmental factor affecting window sizes under the pipeline was observed near Fourth of July Creek in AS 14 on an area outside of the study area. Here water seeped to the surface during the winter months, producing a phenomenon known locally as overflow but more correctly termed "aufeis". As the water seeped to the surface, froze and turned to ice, it created an impediment to subsequent seepage which in turn flowed to the surface, froze, and created an even higher impediment. As ice built up under the pipe and on the pipeline right-of-way, it substantially reduced the window sizes. Observations of moose tracks in the area showed a single adult moose was deflected by the small windows available under the pipe, but eventually selected a crossing location which required it to bend down on its knees to fit under the pipe. The crossing location was approximately 56 inches at BOP-TOP and was similar in height to other windows it had previously refused to cross. Aufeis was not a barrier to moose crossings in any other areas we observed.

Sound

Concern had been expressed that fluctuating oil pressures within the pipeline would produce distracting noises. Only on two occasions were such noises audible to the human ear. These sounds were bubbling noises and were only audible to a human with his ear close to the pipe. Heat radiating pipes located on each vertical support member responded under certain wind conditions in such a way as to produce a sound similar to that produced by wind through power lines. This sound was sometimes loud enough to be easily heard from inside a moving vehicle with the windows closed. There was no way to evaluate the effects of these noises on moose, but caribou were observed crossing under the pipeline during high winds with the corresponding noises.

Icicles

Snow gathered on the top of the pipeline, then melted and ran down the outside of the pipe. Melting water flowed down the side of the pipe,

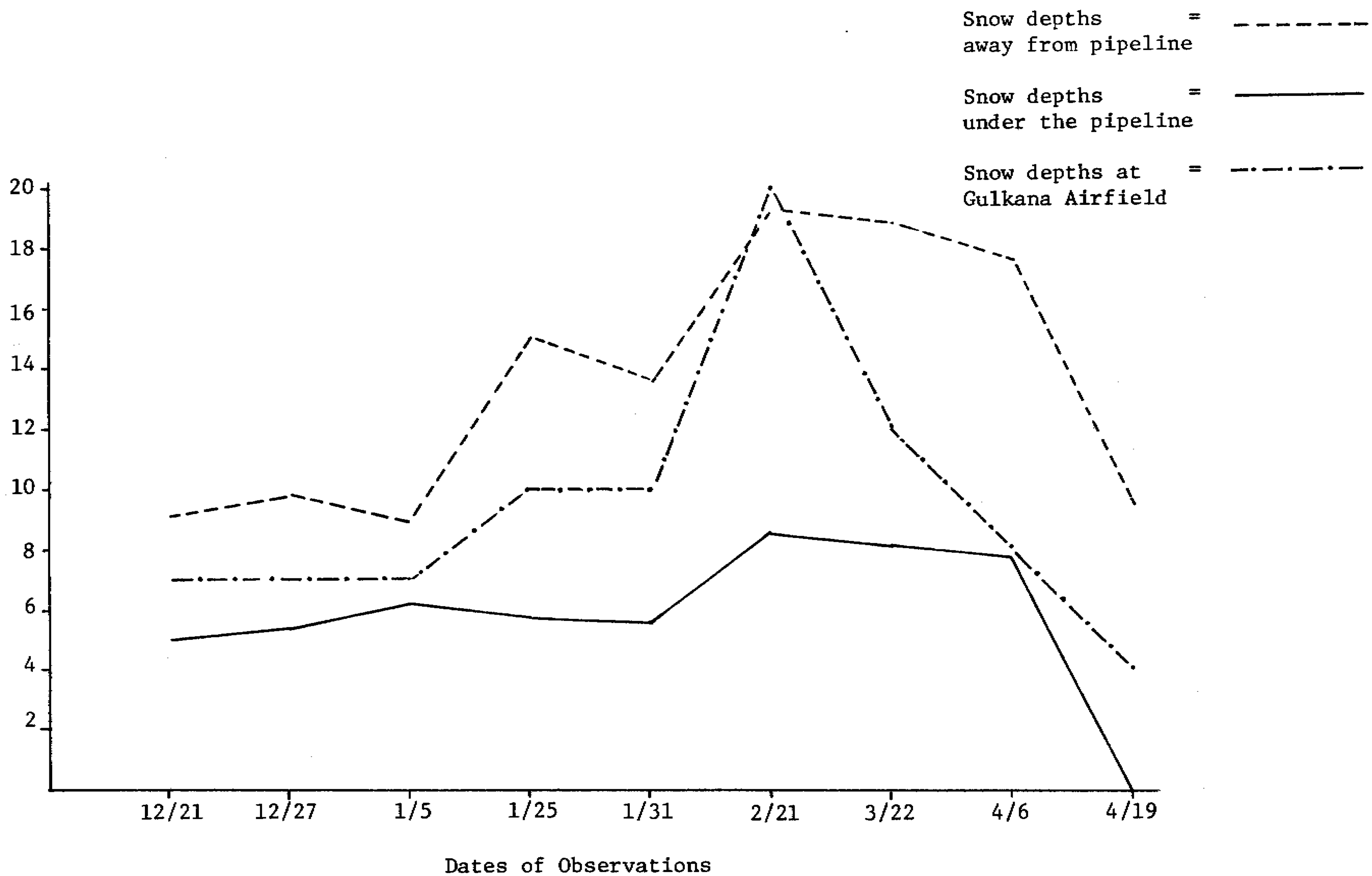


Figure 5. Comparisons of snow depths under the pipeline at AS/22 with snow depths away from the pipeline and snow depths recorded at Gulkana Airfield, December 1977 - April 1978.

Table 12. Indices of winter severity as indicated by monthly maximum snow depths at the Gulkana, Alaska weather station, winter 1967-68 through winter 1977-78. (Data from VanBallenberghe 1968 and from NOAA records).

Winter	Snow Depth Index 1/	Rank of Winter Severity 2/	Mean Snow Depth Per Month 3/	Snow Depth Index Expressed as a Percentage of 35 Year Mean 4/
1967-68	24	1	4	27
1968-69	46	5	8	52
1969-70	31	2	5	35
1970-71	58	11	10	65
1971-72	235	35	39	264
1972-73	43	3	7	48
1973-74	77	18	13	87
1974-75	106	25	18	119
1975-76	51	10	9	57
1976-77	45	4	8	51
1977-78	73	15	12	82

1/ Computed by summing maximum depth of snow on the gound, November through April each year.

2/ Based on 35 winters of record, 1943-44 through 1977-78. Rank 1 represents the shallowest snow depths on record.

3/ Computed by dividing the snow depth index by six, or the number of months in the interval November through April.

4/ Mean snow depth index for 34 winters of record equals 89 inches.

then dropped toward the ground. From time to time icicles formed at this point and projected down towards the pipeline pad. No icicles that we observed exceeded 18 inches in length and they rarely projected below the bottom of the pipe, and then for only an inch or two. Snow under this dripline was compacted and crusted and was generally the same depth as snow away from the pipeline although deeper than snow under the pipe. Icicles and the related snow under the dripline did not form a visible barrier under the environmental conditions encountered during this study.

Comparison with earlier study

VanBallenberghe's (1978) study included an analysis of moose movements as related to window size which is largely identical to that utilized in this study. The major differences were:

1. His study was conducted during the construction phase while this study was conducted during the operational phase of the pipeline.

2. His study lumped window sizes into only three categories prior to statistical analysis (less than 6 feet, 6 to 8 feet, and over 8 feet).

3. Most of his work was conducted on one completed segment of the pipeline, a segment which corresponds with Section 1 of this study.

4. His determination of actual pipeline heights was based on a sampling scheme of physical measurements (VanBallenberghe) rather than on the AS-BUILT specifications in this study.

5. His study was conducted during atypical winter conditions, whereas this one was conducted during a winter of near median snowfall.

Because VanBallenberghe's conclusions about the influence of window sizes on moose movements differed from ours, an effort was made to explain the discrepancies.

When the AS-BUILT data on the proportion of windows of various sizes (Table 2) are converted to VanBallenberghe's lumped categories, no significant differences are observed (Table 13). Thus, the studies are in agreement on the frequency of occurrence of windows of these three sizes in Section 1 of this pipeline.

Although VanBallenberghe's pipeline data do not differ from ours, his conclusions on the pattern of moose crossings through various window sizes were different. When our crossing data are lumped into his categories for the same pipeline section (Section 1) our data suggest that moose utilize windows less than 6 feet high significantly less than expected ($p < 0.05$, $n = 44$ crossings) while his data indicate no variation from expected ($p < 0.05$, $n = 127$ crossings). Our data suggest no variation from expected for windows between 6 and 7.99 feet ($p < 0.30$, $n = 149$) while his data suggest these are utilized significantly more than expected ($p < 0.05$, $n = 346$ crossings). For pipe heights greater than 8 feet, our data suggest these are utilized significantly more than expected ($p < 0.30$, $n = 82$)

Table 13. Comparison of the distribution of above ground pipeline windows of three sizes as determined by VanBallenberghe (1978) from physical measurements of a sample of windows and as determined in the study from AS-BUILT specifications.

BOP-TOP Interval (inches)	Proportion of Total Pipeline Segment	
	VanBallenberghe (1978)	Present Study
<72	.213	.220
72-95	.532	.539
>95	.255	.241

while his suggest these are utilized significantly less than expected ($p < 0.05$, $n = 92$).

Because of VanBallenberghe's larger sample in this section of the pipeline, his conclusions are supported when his data are combined with ours: no significant variation from expected for windows less than 6 feet ($p < 0.20$), windows of 6 - 7.99 feet are utilized significantly more than expected ($p < 0.05$) and windows larger than 8 feet are utilized significantly less than expected ($p < 0.15$).

Deflections

In 955 pipeline encounters, there were 43 occurrences where moose failed to cross the pipeline within one pipeline segment of where they initially contacted the pipeline pad. In 9 of these cases, observers felt the moose may have been involved in activities where they had no intention of crossing the pipeline (feeding, breeding, north-south movements, etc.). The remaining 36 encounters (45) were classified as deflections.

Deflections occurred at various BOP-TOP heights. Table 14 shows the percent of moose deflections and percent of moose encounters at the various pipeline heights. Although the sample size is small, it appeared that moose were more likely to deflect from the pipeline at BOP-TOP heights of less than five feet than higher pipe heights. Approximately 16 percent of the moose that deflected eventually crossed the pipeline after paralleling the line for two or more pipeline segments. In one case track observations indicated a possible separation between a cow and calf where the BOP-TOP height was below 5 feet for several VSM's. Both moose eventually crossed the pipeline but the crossings occurred 16 pipeline segments or over 300 yards apart.

ACKNOWLEDGEMENTS

Most of the field data were gathered by Mark A. Chihuly, who is presently enrolled in Wildlife Science at the University of Alaska. Special recognition is given him for his dedication to this sometimes monotonous and always difficult chore during winter months of deep snow, cold weather and short daylight. Without his ability to keep equipment operating and desire to achieve excellence, much less data would have been gathered.

Deep appreciation is also given to SuSann Miller, a statistician for U.S. Fish and Wildlife Service, for the gift of both her time and considerable talent which enabled us to use and operate the SPSS computer system at the University of Alaska. Without her assistance, the storage and analysis of data would have been extremely difficult, if not impossible.

LITERATURE CITED

Neu, C.W., C.R. Byers, and J.M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38(3):541-545.

Skoog, Ronald O. 1968. Ecology of the Caribou in Alaska. Unpublished Doctorate Thesis, University of California, Berkeley, California. 699pp.

VanBallenberghe, Victor. 1978. Final Report on the Effects of the Trans-Alaska Pipeline on Moose Movements. Special Report No. 23. Joint State/Federal Fish and Wildlife Advisory Team. 40pp.

PREPARED BY:

Sterling Eide and Sterling Miller
Game Biologists

SUBMITTED BY:

Karl Schneider
Regional Research Coordinator

APPROVED BY:

Director, Division of Game

Research Chief, Division of Game

Table 14. Number and percents of moose deflections at various pipeline heights.

BOP-TOP Heights	No. of Moose Encounters	Moose Crossings No.	(%)	Moose Deflections No.	(%)	Questionable Deflections No.	(%)
Buried	45	41	(91)	3	(7)	1	(2)
<5'	12	6	(50)	5	(42)	1	(8)
5-5.99'	144	139	(96)	4	(3)	1	(1)
6-6.99'	225	215	(96)	7	(3)	3	(1)
7-7.99'	218	207	(95)	11	(5)	--	--
8-8.99'	133	131	(98)	2	(2)	--	--
9-9.99'	102	99	(97)	2	(2)	1	(1)
10-10.99'	56	54	(96)	2	(4)	--	--
11-11.99'	11	11	(100)	--	--	--	--
12+'	9	9	(100)	--	--	--	--
Total	955	912	(95)	36	(4)	7	(1)