Attachment B

11-3

ALASKA INTERTIE SNOW LOAD MITIGATION REPORT

DRAFT

Prepared for:

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1.0 INTRODUCTION

The Alaska Energy Authority contracted Dryden & LaRue, Inc. (D&L) to assist in evaluating options for mitigating unbalanced snow loads on the Alaska Intertie. The purpose of this report is to provide basic information to the Intertie Operating Committee. The report describes possible mitigation options along with costs and benefits for each option. The options presented have not been designed and are only conceptual. No conclusions or recommendations are included; the goal of this report is to provide budgetary level cost estimates and describe the Pros/Cons of mitigations options.

Construction of the Alaska Intertie was completed in 1984. The line connects Douglas Substation in Willow to Healy Substation. The Intertie is owned by The State of Alaska and is currently maintained by Matanuska Electric Association (MEA) and Golden Valley Electric Association (GVEA). The line is constructed of Steel X-towers that are generally 80 feet in height with typical spans of 1100 to 1300 feet and a typical ground clearance of 30'. A bundled 954 ACSR cable is used for the conductor. The line is insulated at 345kV but is currently operated at 138kV.

An investigation in January 1989 revealed that when one section is heavily loaded with snow and ice and adjacent spans are relatively bare the conductor can move into the more heavily loaded span and reduce ground clearance. Unbalanced loads cause the tensions to equalize and the insulators swing towards the loaded span. A small amount of insulator movement greatly effects ground clearance. There are many factors on the Intertie that make this relatively problematic. The long insulator strings (345kV) allow a large amount of horizontal movement without much vertical displacement. The line also contains many long spans and many locations with short spans adjacent to long spans.

This unbalanced loading and reduced ground clearances undoubtedly happens on many other lines in snow country. Although the line is located several miles from the Parks Highway, the area has become a popular recreation location in recent years. Snowmobiles, dogsleds, and skiers often traverse the right-of-way.

Since the installation, there have been three documented instances of low ground clearance; 1988, 1990, and 1995. In 1996 it was decided to install a Snow Load Monitoring System (SLMS) on the first 55 miles of the Intertie. This section of the line is the most accessible to recreational activities and includes the areas of the line with documented clearance issues. The SLMS was installed to identify conditions that may lead to possible clearance issues. The system monitors the line from Douglas Substation to approximately 7 miles north of the Talkeetna River (Tower 231). The SLMS contains load cells and inclinometers on 24 towers or approximately every 2.5 miles. The load cells monitor the weight of snow load on one phase and the inclinometers register the swing of all three insulators. Although the SLMS has historically worked well, there has not been any clearance issues discovered since it was first operated in 1997. However, it does have limitations. The stations are only installed every 10th tower so it is possible a clearance problem could occur without being detected by the surrounding monitors.

Also, load cells are installed only on one phase. In 2001 the SLMS was augmented with a snow machine ground patrol. These patrols document conditions after a snow storm and allow for human observations.

2.0 MITIGATION OPTIONS

There are two major mitigation options under consideration for the Intertie. Option 1 will improve the ground clearance by shortening the insulator strings, tightening up the conductor, removing the guy yokes and pretensioning the guy wires. This will increase ground clearance so that an unbalanced condition would need to be more severe to reduce ground clearance. Option 2 will install inset towers at approximately mid-span and effectively eliminate the possibility of reduced ground clearances. This option was originally conceived as placing an inset at each and every mid-span. However, selecting the more critical locations could reduce the work. This is presented as option 2-B. The next section of the report will evaluate these options.

2.1 Option 1

This option will modify existing components of the line to increase the normal ground clearance. An increase in ground clearance means that a more severe unbalanced loading condition can be tolerated. It is possible that a very severe unbalanced loading condition could still reduce ground clearances.

The line components modified by this option are:

Shorten insulator strings
Remove yokes
Pretension guys
Remove spacers
Remove one conductor
Resag conductor

In order to estimate the effects of modifying components it is necessary to model the system. The model simulation is based on basic assumptions that intend to represent reasonable conditions. The calculations are based on an unbalanced show load of 4 inches radial snow with a density of 5 lb/ft^3. One span is assumed to be loaded in the middle of a long tangent of bare spans. The towers before modification are assumed to have a conductor attachment height of 80 feet and spans are assumed to be 1,260 feet.

Based on these assumptions, the unbalanced, loaded, ground clearance of 30 feet will be increased by about 14 feet. It is important to note that this increased clearance is only for the assumptions stated above. Loading conditions outside these assumptions will produce a different change in ground clearances. Removal of one subconductor does not affect the possible ground clearance because the loading is per conductor. However, if the snow load were to become large enough to bridge the 18 inch spacing between the conductors then removal of one subconductor would have a beneficial effect. This option includes resagging the conductor, which is not practical without removal of the spacers. If the spacers need to be removed, then removal of one subconductor is logical.

2.1.1 Construction Cost Estimate & Outage Duration

At this level of review, all aspects are conceptual including cost estimates. The estimated cost to modify the line components as described above is $6 to $7.3 million. Based on 30 workers, this is roughly 6 to 7 months construction. Since almost all of the modifications are associated with the insulators or conductor, an outage will be required for most of the construction period, about 5 to 6 months.

2.1.2 Pros and Cons

If the above components are modified there will be an increased ground clearance for both normal and unbalanced load conditions. This increase will allow for normal line operation under more severe conditions, but will not solve the problem. Removal of one subconductor will create overbuilt towers and stiffen the whole system.

- <u>Pros</u>

  Increased ground clearance
  Reduced tower loads

- <u>Cons</u>

  Increased ground clearance will still not satisfy all possible loading conditions
  Removal of conductor reduces line capacity
  Removal of insulators eliminates voltages above 230kV
  SLMS monitoring will need to be modified
  Ground Safety Patrols still required

2.2 Option 2

Option 2 will involve placing new structures mid-span along the line. The new structures will increase ground clearance by about 38 feet and essentially eliminate the clearance issues due to unbalanced snow loading. The line will remain bundled and insulated at 345kV. Removing the yokes and pretensioning the guys would not be required either. Installing inset structures will require heavy equipment for installing the foundations and anchors. Consequently, access to the site will dramatically affect the cost of the project. It is expected that about half the sites will be accessible only by helicopter. Overland access to the insets will help reduce costs but may require permitting.

The current line utilizes steel X structure that are guyed ahead and back to a pair of anchors. However, installing an X structure mid-span on an existing line would be very difficult without removing the shield wires and conductors. Instead, V structures can be utilized for the inset structures. After spreading the shield wires, the V structure can be lowered through the phase conductors with a heavy lift helicopter. Once the legs of the V structure have been lowered through the conductors the base of the legs can be pulled together and pinned at the foundation. A sketch of a typical tangent V structure is shown in Appendix A. A similar solution was used for inset towers along the Swan-Tyee Transmission Line in Southeast Alaska.

Placing a structure within an existing span will cause the adjacent insulators to swing away from the inset structure. However, if inset structures are located at mid-span and placed between every tower, then the wire tensions will remain equalized from span to span and the insulators will remain plum. Unfortunately, placing a new structure mid-span or even on every span will not always be practical. Often there are streams or gullies that will conflict with foundations and anchors. If inset structures are shifted from mid-span or not placed in every span then the conductor will have to be re-sagged or at least re-clipped until the insulators become plumb. An alternative to resagging and difficult locations is to install a deadend.

Deadend structures will be more costly, but they will have added benefits to adjacent spans. Deadends structures prevent the tensions from equalizing and can reduce insulator swing in nearby spans. For example, it is not possible to install an inset structure on the 1300 feet span across Sheep Creek. However, a deadend placed on the adjacent spans would help mitigate an unbalance snow load in that area.

Because the spans lengths vary from about 500 feet to 2200 feet, there are several possible ways to locate inset structures. The most thorough and most costly method would be to install a mid-span structure everywhere within the study area. This would require the installation of about 220 structures. However, the number of inset structures may be reduced significantly; if inset structures were placed on only spans that crossed roads, named rivers, or were over 1200 feet. This would reduce the number of inset structures to about 140. However, installing a reduced quantity of inset structures may not completely eliminate ground clearance issues.

2.2.1 Construction Cost Estimate & Outage Duration

Appendix B shows a breakdown of the cost estimate for the project. Installing an inset structure at every location (Option 2-A) is estimated to cost $19 to 23 million. Construction would take about 7 to 9 months with an outage time from 4 to 5 months. If the number of inset structures is reduced (Option 2-B) to around 140 structures the estimated cost would be $14 to 17 million, with a construction season of 5 to 6 months with an outage time of 4 to 5 months.

2.2.2 Pros and Cons

Installing an inset structure at every location should effectively eliminate the clearance concerns due to unbalanced snow loading. This is the most effective and most expensive option. However, reducing the number of inset structures or adjusting the mitigation area can reduce costs.

- Pros
  Essentially Eliminates Clearance Problems due to Unbalanced Loading
  Maintains Capacity & Voltage Upgrade Potential
  SLMS & Ground Patrols No Longer Required

- Cons
  Most Expensive
  Permitting may be required for Access
  Slight Increase in Maintenance Costs

2.3 SLMS Upgrade

When clearance concerns first became apparent in the 1990s several options were evaluated, including the first two options described above. However, because the rarity of major unbalanced loading events, it was determined that monitoring the line was the most cost effective method. However, like all untested systems, the monitoring system has encountered events not fully anticipated. The system has performed well, but there is the possibility of a snow-loading event going undetected by the system.

Since the SLMS design was completed in 1996, data collection and communication technology has dramatically improved. There are more reliable methods of downloading data from the remote stations and other methods of monitoring the line. For example, the SLMS currently uses modems and cell phones to transfer data from the remote stations to the operators at a base station computer. Because of the remote locations, cell phone service is not reliable and is a large power drain on the remote station's batteries. Replacing the cell phones with a low power radio transmitter would improve the communication capabilities and reliability of the SLMS. In addition to improving the reliability, new technology can be utilized to collect additional information on the Intertie. For example, a distance-measuring device would be used to indirectly measure the sag of the conductor rather than inferring the estimated sag of the conductor from the load cell and insulator inclinometers. Remote cameras have also improved considerably since the SLMS was first installed. Cameras can be installed on the Intertie to possibly give operators an actual picture of field conditions.

Improving the SLMS is a research and development effort, therefore the effectiveness of the improvements will not be fully known until the upgrades are actually constructed. Application of more advanced technology is essentially a "how much do you want to spend" scenario. A reasonable starting point could be to budget a cost and then determine the maximum benefits for the money. Following are some probable impacts of this scenario.

- Pros

  Least Costly
  Climate/Loading Data Collected for Future Designs

- Cons

  Only Monitors Line/ No Mitigation
  Requires continued ground patrols
  Increase in Maintenance Costs

3.0 SUMMARY

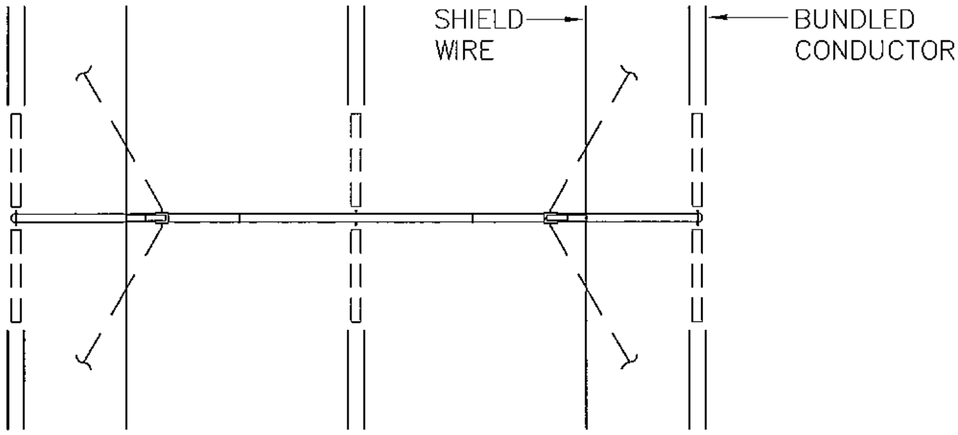
All costs and construction durations are only budgetary. Clearance improvements are generalized, and only estimated. The spans throughout the system vary greatly; therefore the estimated clearance gain will vary considerably throughout the line. Sketches of conceptual structures are in Appendix A and Cost Estimates are located in Appendix B. A table showing road and river crossings of the Intertie as well as long spans can be found in Appendices C and D. A summary of the report follows in Table 1.

ANCHORAGE/FAIRBANKS INTERTIE
UNBALANCED SNOW LOADING OPTIONS

Table 1 Summary of Mitigation Options

	Option 1	Option 2-A	Option 2-B
Option Description	Remove Yokes, Pretension Guy Wires, Remove 1 Conductor & Resag	Inset Towers at every location from Willow to the Talkeetna River (220 Towers)	Inset Towers at critical locations from Willow to the Talkeetna River (140 Towers)
Construction Cost	$6 - 7.3 Million	$18.9 - 23.1 Million	$13.8 - 16.9 Million
Construction Duration	22 - 27 Weeks	31 - 38 Weeks	21 - 26 Weeks
Outage Duration	19 - 23 Weeks	15 - 19 Weeks	17 - 21 Weeks
Pros	Increased ground clearance Reduced tower loads	Essentially Fixes Clearance Issues Line Capacity Unaffected Voltage Uprade Potential Patrols No Longer Required SLMS No Longer Required	Same as Option 2-A
Cons	Some Loads not Mitigated Reduces Line Capacity Reduces Line Insulation SLMS Requires Modification Patrols Still required	Most Expensive Access Permitting May be Required Slight Increase in Maintenance Costs	Same as Option 2-A

Appendix A – Conceptual Sketches



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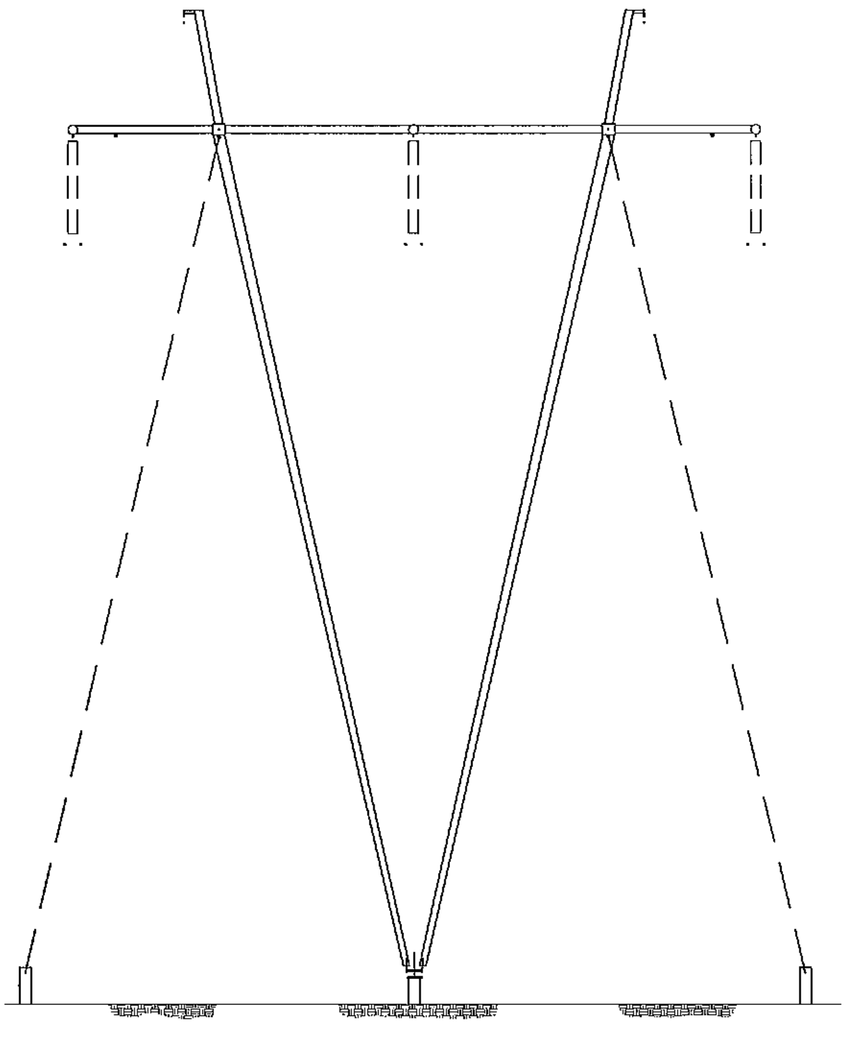

ALASKA ENERGY AUTHORITY

ALASKA INTERTIE SNOW LOAD MITIGATION

Dryden & LaRue, Inc.
CONSULTING ENGINEERS

V–DEADEND

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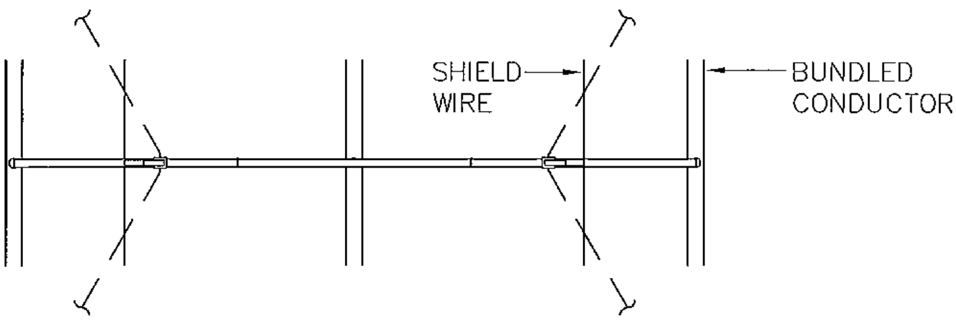

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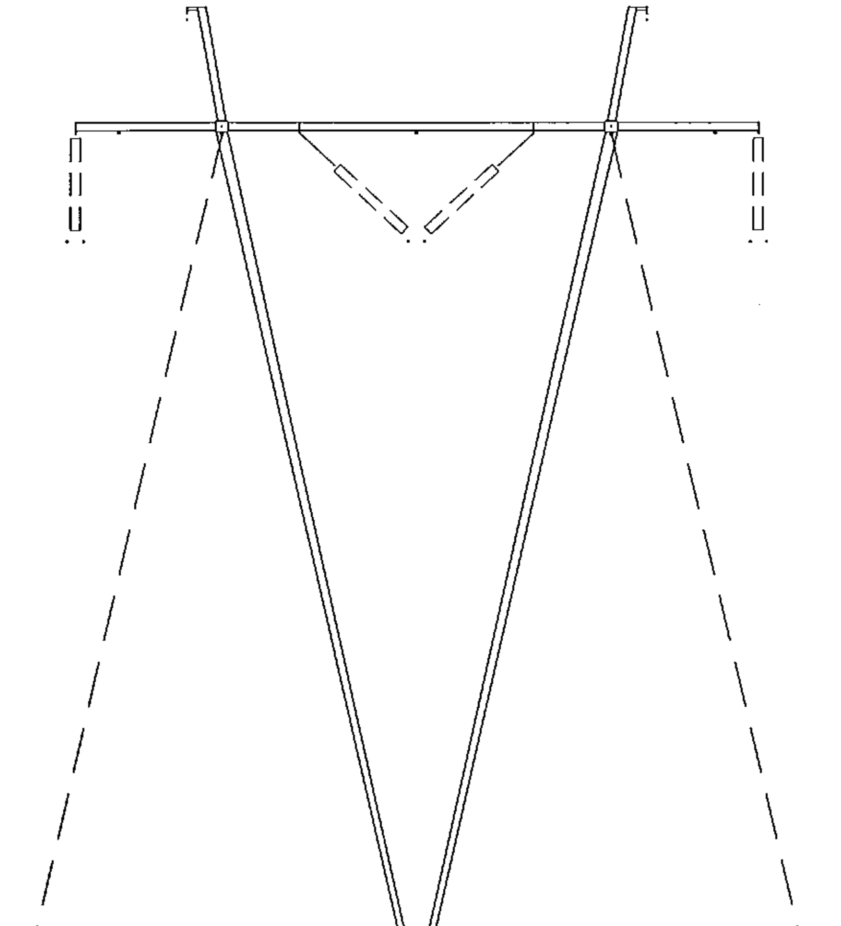

ALASKA ENERGY AUTHORITY

ALASKA INTERTIE SNOW LOAD MITIGATION

Dryden & LaRue, Inc.
CONSULTING ENGINEERS

V–TANGENT

DATE: 4-9-04 PROJECT: AEARPRT
FILE NAME (CADD): D:\PROJECTS\AEARPRT\V-TAN.DWG

Appendix B – Construction Estimates

ANCHORAGE/FAIRBANKS INTERTIE
UNBALANCED SNOW LOADING OPTIONS

CONSTRUCTION COST ESTIMATE

Option 1:
Remove Yoke, Pretension Guy, Shorten Insulator, Remove One Conductor from Bundle & Resag

Item	Quantity		Unit Labor		Total
Remove Spacers	2640	each	$300		$792,000
Remove Conductor	792	kfeet	$1,000		$792,000
Shorten Insul	660	each	$1,000		$660,000
Resag Conductor	792	kfeet	$3,500		$2,772,000
Remove Yokes	440	each	$600		$264,000
Pretension Guys	880	each	$300		$264,000
Misc.(20%)	1	lot			$1,108,800
				Total	$6,652,800
				Range ±10%	**$6 - 7.3 Million**
				Construction Time Range	22 - 27 Weeks
				Outage Time	19 - 23 Weeks

Option 2-A:
Install Inset Structures at all Locations within Study Area

Item	Quantity		Unit Labor	Unit Mtrl	Total
Fnd/Anc w/access	550	each	$2,000	$1,000	$1,650,000
Fnd/Anc w/copter	550	each	$10,000	$1,000	$6,050,000
Tower Assembly	220	each	$3,000	$12,000	$3,300,000
Inset w/access	110	each	$8,000		$880,000
Inset w/helicopter	110	each	$30,000		$3,300,000
Wire Connection	660	each	$2,000	$500	$1,650,000
Resag Conductor	198	kfeet	$3,500		$693,000
Misc. (20%)	1	lot			$3,500,000
				Total	$21,023,000
				Range ±10%	**$18.9 - 23.1 Million**
				Construction Time Range	31 - 38 Weeks
				Outage Time	15 - 19 Weeks

ANCHORAGE/FAIRBANKS INTERTIE
UNBALANCED SNOW LOADING OPTIONS

CONSTRUCTION COST ESTIMATE

Option 2-B:
Install Inset Structures at critical locations within study area

Item	Quantity		Unit Labor	Unit Mtrl	Total
Fnd/Anc w/access	350	each	$2,000	$1,000	$1,050,000
Fnd/Anc w/copter	350	each	$10,000	$1,000	$3,850,000
Tower Assembly	140	each	$3,000	$12,000	$2,100,000
Inset w/access	70	each	$8,000		$560,000
Inset w/helicopter	70	each	$30,000		$2,100,000
Wire Connection	420	each	$2,000	$500	$1,050,000
Resag Conductor	594	kfeet	$3,500		$2,079,000
Misc (20%)	1	lot			$2,560,000
				Total	$15,349,000
				Range ±10%	**$13.8 - 16.9 Million**
				Construction Time Range	21 - 26 Weeks
				Outage Time	17 - 21 Weeks

Notes:

1. Estimate based on 50 miles of line
2. One half of foundations/anchors are assumed to be overland accessible
3. One half of towers are assumed to be overland accessible
4. Estimated manhour cost assumed to be $150
5. Construction time based on 30 working men at 60 hours per week
6. For Option 1: About 75% of construction time assumed to require line outage
7. For Option 2: Foundation & Tower Assembly work assumed to not require an outage, 25% of miscellaneous & 100% of tower & wire work assumed to require an outage
8. For Option 2: Resag does not require removal of spacers
9. For Option 2-A: Resagging is required for 25% of the existing structures
10. For Option 2-B: Resagging is required for 75% of the existing structures

Appendix C – Long Span Locations

APPENDIX C

ANCHORAGE/FAIRBANKS INTERTIE
UNBALANCED SNOW LOADING OPTIONS

LONG SPAN LOCATIONS

Span Location		Span	Hot Curve	
Back Tower	Ahead Tower	Length (ft)	Est. Clearance (ft)	Comments
2	3	1290	32	
4	5	1227.17	31	
5	6	1350	32	
6	7	1285	31	
7	8	1290	31	
8	9	1250	31	
9	10	1225	32	
10	11	1250	31	
13	14	1225	32	
14	15	1275	32	Inset Tower 425' from Tower 15
15	16	1250	31	
16	17	1200	30	
17	18	1250	31	
19	20	1225	31	
22	23	1200	33	
24	25	1250	30	Creek at Mid, Install DE on Adjacent Spans
25	26	1200	32	
26	27	1275	31	
27	28	1250	31	
28	29	1250	30	
31	32	1250	31	Inset DE Tower 400' from Tower 31
32	33	1250	31	
33	34	1300	32	
34	35	1300	32	
35	36	1225	32	
36	37	1200	32	
37	38	1210	32	
38	39	1265	31	
39	40	1275	32	
40	41	1300	33	
41	42	1325	31	
42	43	1275	32	
43	44	1275	32	
44	45	1300	32	
45	46	1275	31	
46	47	1275	31	
47	48	1300	32	
48	49	1275	32	
49	50	1300	33	
52	53	1350	30	
54	55	1250	32	
56	57	1290	35	River at Mid, Install DE on Adjacent Spans
57	58	1260	30	
58	59	1260	31	
59	60	1240	31	

Span Location Back Tower	Ahead Tower	Span Length (ft)	Hot Curve Est. Clearance (ft)	Comments
60	61	1275	30	
61	62	1225	31	
62	63	1275	31	
63	64	1325	29	
64	65	1200	34	
65	66	1225	32	River @ Mid, Install DE on Adjacent Spans
67	68	1225	32	
68	69	1325	30	
69	70	1295	31	River at Mid, Install DE on Adjacent Spans
72	73	1300	31	River at Mid, Install DE on Adjacent Spans
73	74	1250	33	
78	79	1225	31	
79	80	1225	31	
85	86	1260	31	Inset Tower 450' from Tower 86
88	89	1250	30	
89	90	1250	30	Inset Tower 475' from Tower 89
90	91	1200	31	
95	96	1250	32	
96	97	1250	32	
97	98	1285	29	
98	99	1265	30	
99	100	1250	31	
100	101	1325	30	
105	106	1250	35	
107	108	1200	32	
108	109	1250	34	
109	110	1300	33	
110	111	1275	31	
111	112	1215	27	
112	113	1295	30	
117	118	1250	33	
118	119	1725	32	
122	123	1225	28	
128	129	1380	28	Creek at Mid, Install DE on Adjacent Spans
130	131	1350	31	
131	132	1250	29	
132	133	1200	29	
133	134	1320	34	
134	135	1604	29	
136	137	1350	32	
137	138	1250	31	
138	139	1300	30	
139	140	1325	30	
140	141	1575	35	
141	142	1275	31	
147	148	1235	31	
148	149	1225	31	
149	150	1375	33	
150	151	1375	33	

Span Location		Span	Hot Curve	
Back Tower	Ahead Tower	Length (ft)	Est. Clearance (ft)	Comments
152	153	1500	31	
153	154	1500	34	Install 2 Inset Structures
154	155	1525	34	
160	161	1225	32	
161	162	1400	33	
162	163	1275	31	
164	165	1550	31	Install 2 Inset Structures
170	171	1225	33	
171	172	1250	31	
173	174	1287	60	Inset Not Practical
176	177	1232	37	
177	178	1250	30	
180	181	1400	30	
181	182	1225	30	
184	185	1250	30	
185	186	1400	34	
188	189	1650	43	
195	196	1425	43	River, Install 2 DE on near spans
197	198	1325	30	
198	199	1225	35	
199	200	1300	31	
203	204	1350	32	
206	207	1200	31	
210	211	1472	30	
216	217	2200	45	Install DE between 217-218
218	219	1299	31	
222	223	1535	30	
223	224	1865	38	
227	228	1375	34	Midspan Not possible
228	229	1225	34	
229	230	1300	35	

Summary

Span	Qnty
1200-1299	82
1300-1399	27
1400-1499	5
1500-1599	6
1600-1699	2
1725	1
1865	1
2200	1
Total	125

Appendix D – River & Road Crossings

APPENDIX D

ANCHORAGE/FAIRBANKS INTERTIE
UNBALANCED SNOW LOADING OPTIONS

LONG SPAN LOCATIONS

River/Road Name	Span Location Back Tower	Span Location Ahead Tower	Span Length (ft)	Critical Hot Curve Est. Clearance (ft)	Estimated Location within Span	Estimated Clearance over Road/River (ft)
Willow Creek Road	1	2	980	43	Mid	44
Caswell Road	68	69	1325	30	1/5	55
Caswell Lakes Road	69	70	1295	31	3/5	41
Caswell Lakes Road	70	71	1030	31	Mid	37
Yoder Road	129	130	920	67	2/5	70
North McKinley Ave	82	83	1150	31	4/5	46
Future Road	106	107	1150	30	3/5	35
LeRoy Drive	115	116	900	31	3/4	47
Cat Trail	92	93	1075	31	3/5	34
Trail (From Mastadon Rd)	154	155	1525	34	3/5	36
Willow Creek	2	3	1290	32	9/10	68
Willow Creek	3	4	1143	35	1/3	48
Willow Creek	3	4	1143	35	2/5	38
Rogers Creek	11	12	1148	31	5/8	35
Little Willow Creek	22	23	1200	32	2/5	34
196 Mile Creek	44	45	1300	31	5/8	33
197 1/2 Mile Creek	49	50	1300	33	2/5	37
Kashwitna River	56	57	1290	31	Mid	31
Caswell Creek	65	66	1225	31	Mid	40
Sheep Creek	72	73	1300	31	Mid	35
Sheep Creek	73	74	1250	32	Mid	35
Goose Creek	96	97	1250	32	Mid	33
Montana Creek (N Fork)	144	145	934	32	2/5	34
Montana Creek (N Fork)	146	147	1065	30	3/4	44
Answer CK	154	155	1525	35	Mid	35
Talkeenta Fork	193	194	1175	33	3/5	50
Talkentna Fork	194	195	800	40	Mid	40
Talkeetna River	195	196	1425	45	2/5	45
Unnamed Stream	8	9	1250	30	3/5	36
Unnamed Stream	14	15	1275	33	1/2	33
Unnamed Stream	30	31	1160	34	3/8	35
Unnamed Stream	31	32	1250	30	Mid	30
Unnamed Stream	37	38	1210	31	2/5	36
Unnamed Stream	43	44	1275	32	1/3	46
Unnamed Stream	85	86	1260	31	Mid	31
Unnamed Stream	86	87	1138	32	2/5	35
Unnamed Stream	89	90	1250	30	Mid	31
Unnamed Stream	95	96	1250	32	Mid	33
Unnamed Stream	100	101	1325	31	3/4	50
Unnamed Stream	103	104	1020	34	Mid	34

APPENDIX D

River/Road Name	Span Location Back Tower	Span Location Ahead Tower	Span Length (ft)	Critical Hot Curve Est. Clearance (ft)	Estimated Location within Span	Estimated Clearance over Road/River (ft)
Unnamed Stream	117	118	1250	33	2/5	35
Unnamed Stream	126	127	950	30	3/5	40
Unnamed Stream	128	129	1380	28	Mid	29
Unnamed Stream	130	131	1350	32	1/4	79
Unnamed Stream	135	136	1145	29	Mid	89
Unnamed Stream	138	139	1300	30	3/5	35
Unnamed Stream	139	140	1325	30	1/3	60
Unnamed Stream	152	153	1500	31	1/3	46
Unnamed Stream	156	157	1175	33	3/5	35
Unnamed Stream	174	175	1050	38	Mid	38
Unnamed Stream	218	219	1299	70	Mid	72

Summary:
8 Spans cross Roads
2 Spans cross Plotted trails
17 Spans cross Named Rivers
23 Spans cross unnamed streams